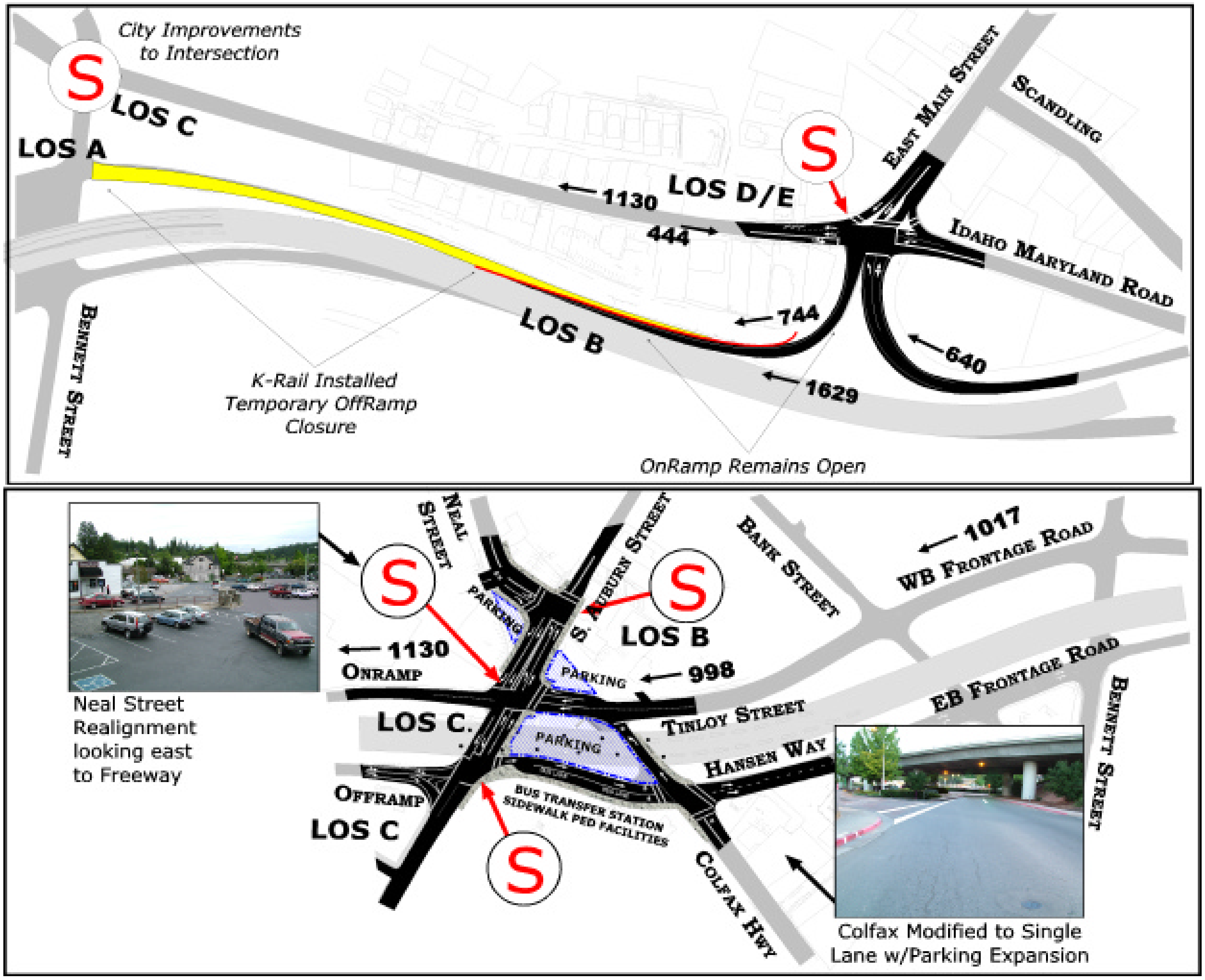
GRASS VALLEY CORRIDOR IMPROVEMENT PROJECT
DRAFT REPORT



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Introduction

The purpose of this report is to document the existing and proposed future traffic conditions along the "Grass Valley Corridor Improvement Project" (GVCIP) which is defined as the system of roads and freeway ramps extending from Idaho Maryland Road / SR 20/49 EB ramp intersection on the east to the South Auburn Street / SR 20/49 ramp intersections on the west. Figure 1 shows the study area.

The existing traffic volumes are shown on the figure along with the levels of service (LOS) at the study intersections. LOS E and LOS F conditions exist today along the corridor at several locations including Idaho Maryland Road at SR 20/49 EB ramps, Idaho Maryland Road at SR 20/49 WB ramps, and South Auburn Street at the SR 20/49 WB Onramp and Neal Street, as well as Colfax Avenue and the SR 20/49 WB Frontage Road.

On the SR 20/49 freeway, the level of service at the Idaho Maryland Road Onramp weave with the Bennett Street Offramp traffic is currently at LOS D and projected to go to LOS E conditions in the near future (approximately two years). In order to mitigate this critical freeway weave, as well as the Main Street corridor and Colfax/Auburn/Neal triangle area, the GVCIP was developed.

For example, the Main Street corridor experiences high levels of traffic and is at LOS F conditions for several locations including the Idaho Maryland intersection. A signal would mitigate this intersection to LOS C conditions, but the side effect of sending platoons of traffic onto the onramp would negatively impact the critical freeway weave.

This study developed transportation mitigation solutions that are sensitive to these issues, and which solve the big picture, and not just isolated locations. The frontage road system has the available capacity and was utilized in the corridor solution to mitigate overloaded freeway ramps and surface street systems.

Analysis Methods

Due to the complex nature of traffic operations, it is not always possible to adequately describe some traffic conditions with conventional traffic engineering methodology.

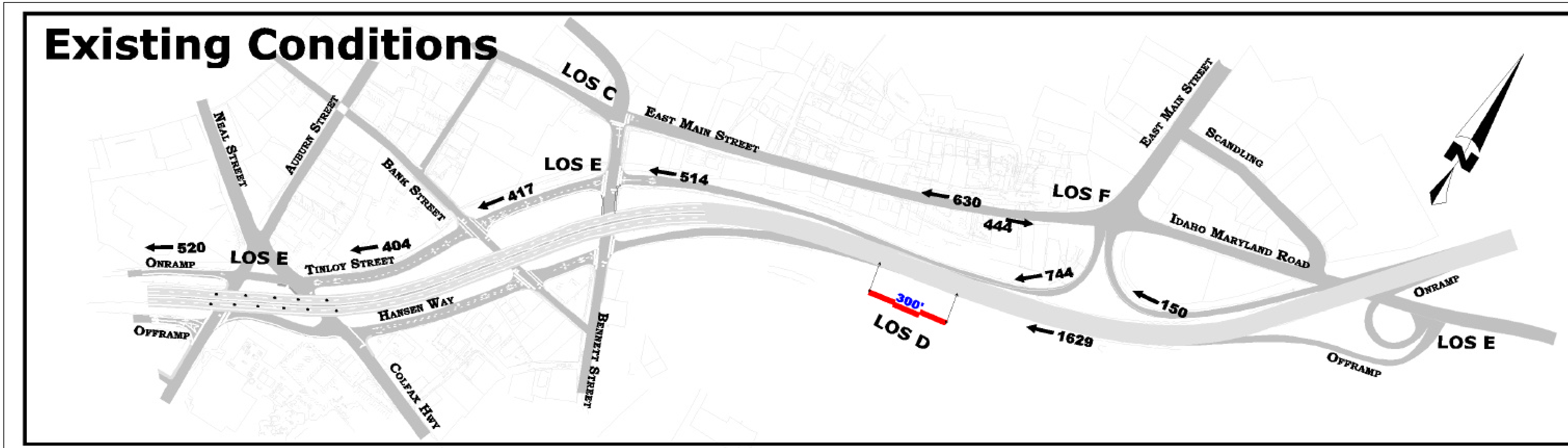


Figure 1 Grass Valley Corridor Improvement Project Study Area, Year2004 Existing Conditions, PM peak Hour

Typically, turning movements at an intersection are entered into a software program (software patterned after methods defined in the Highway Capacity Manual (HCM)), and a delay and LOS value are reported. The intersection-only method in the HCM does not take into account the dynamics that can take place of traffic overflows between closely spaced intersections, or even between intersections that are spaced properly but which are overloaded and moving traffic inefficiently.

Because of the limitations of the HCM methods, the level of service reported for an intersection may not adequately represent the conditions taking place in the field, because there may be other factors (such as a merge ramp, a busy driveway, backing traffic from one intersection to another, etc.) that are not accounted for in the HCM methodology. Chapter 31 of the HCM describes the relationship of various methods used to project and analyze traffic level of service, etc. Figure 2 shows this chart from the HCM (Exhibit 31-1).

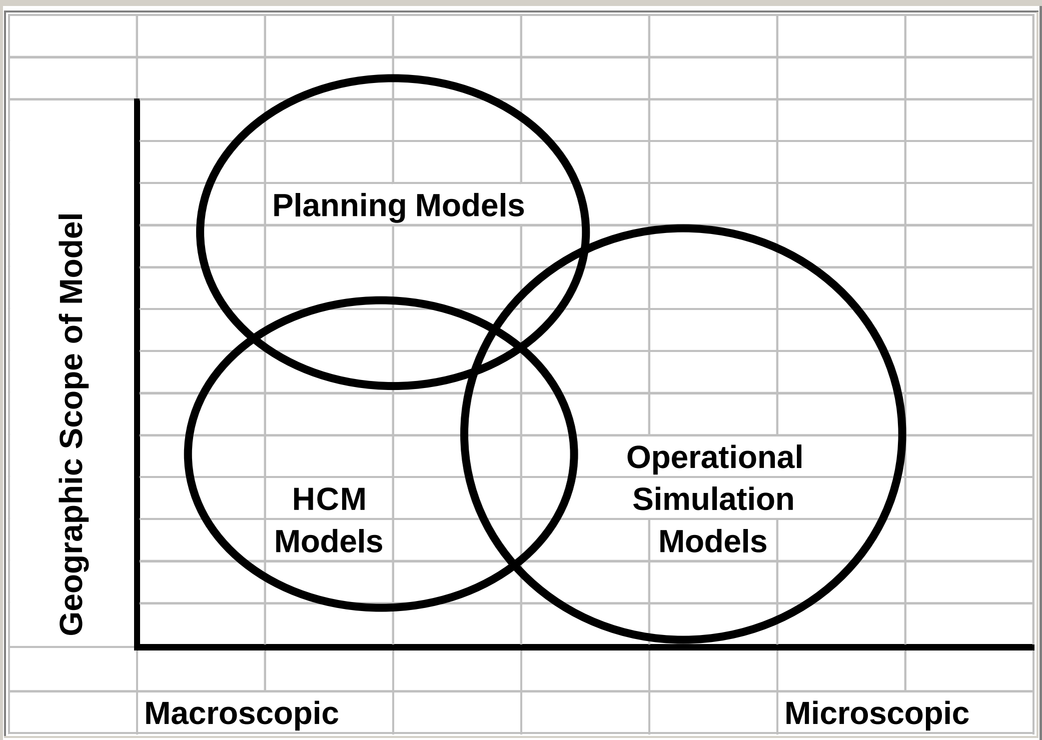


Figure 2 Exhibit 31-1. Continuum of Traffic Models

What Figure 2 communicates is that Operational Simulation Models are more microscopic in nature, or in other words, have more detail and show more information.

Besides the HCM models used in this study, other software was also used, specifically, an operational simulation model SynchroPro and the companion model SimTraffic. The latter model can visually simulate the movement of each vehicle through the system of streets and intersection lanes and turning movements. The software operates according to the specific traffic count data, street geometric details entered for each street segment, and the specific number of turning lanes and type for each approach. In addition, the software simulates signal timing, so that vehicles only move through the intersection when they get a "green light." If an adjacent intersection is not able to sufficiently move traffic through the intersection for a particular approach, then this traffic begins to back up and build in queue length, until sometimes it backs to the adjacent intersection. When this happens, the intersection affected is not able to move traffic as it is "blocked" and this is reflected visually in the SimTraffic software. When traffic is blocked due to an adjacent intersection experiencing overload conditions, this causes the blocked vehicles to wait at their intersection approach while their green light soon turns to red, and they must wait another signal cycle.

In an effort to better describe traffic conditions it is necessary to do a traffic operations analysis which includes looking at a number of traffic related factors, and taking all into consideration in making an assessment of the traffic conditions. These include system-type factors including:

1. Turning movement volumes at each intersection
2. Intersection geometry (number of lanes and type)
3. Signal timing
4. Intersection approach turn pocket lengths
5. Distance between intersections in feet or miles
6. Speed limits and vehicle speeds observed and measured
7. Vehicle type (car, truck, bus, etc.)
8. Measured delay in driving system during peak times
9. Origin / Destination sampling

In a typical traffic impact study, only number 1 and 2 above and possibly number 3, are given consideration in reporting the level of service at an intersection, using the HCM methodology. It is more "broad brush" in the methodology, but is typical of industry standard for traffic impact studies which are geared to determine if any impacts take place, and if mitigation measures are required.

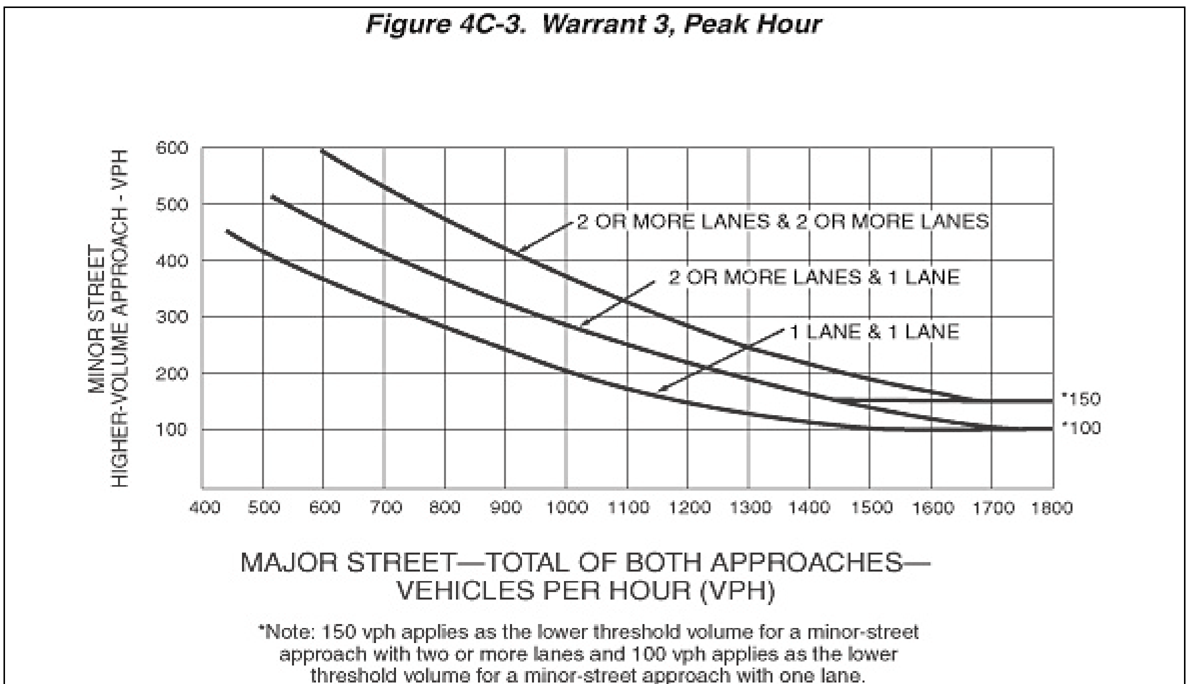
Occasionally there are circumstances where a particular HCM methodology (or “model”) does not always accurately represent the traffic conditions in the field. Figure 2 was prepared to illustrate that there are several methods or models available, and professional judgment is needed to determine which one is the most appropriate, or possibly a combination of several. In this study, all three types of models shown in Figure 2 were utilized to determine traffic projections for the future and the corresponding levels of service for the roadway segments, section, and intersections.

EXISTING YEAR 2004 CONDITIONS

The traffic conditions along the study corridor are generally at LOS E to LOS F conditions today. The frontage roads from Bennett Street to Colfax Avenue are generally under-utilized from a capacity standpoint, and are at LOS A conditions. Each frontage road has two lanes of travel, and is an ideal facility to which more traffic can be diverted to lessen future traffic impacts to parallel roads and freeway facilities. Data was collected and assembled to establish existing traffic volumes and traffic patterns in the study area.

Signal Warrant Summary

The signal warrant criteria for *Warrant 3: Peak Hour* is shown in Figure 3 below (Figure 4C-3 from the Manual on Uniform Traffic Control Devices). These can also be found in the Caltrans Traffic Manual. Table 1 shows the specific approach volumes used in the warrant analysis, and whether the criteria is met for each study intersection. The existing turning movement counts for each of the study intersections is given graphically in Figure 4. Table 2 shows the interim condition after the Bennett Street Ramp is closed.



Source: MUTCD

Figure 3 Signal Warrant Criteria for Peak Hour Traffic Volumes

TABLE 1
SIGNAL WARRANT AND PEAK HOUR VOLUMES SUMMARY
FOR EXISTING YEAR 2004

Major Total VPH	Minor Total VPH		Signal Warr?	N/S Street	E/W Street	E-W MAJOR ST?	Southbound RT	Southbound THRU	Southbound LT	Westbound RT	Westbound THRU	Westbound LT	Northbound RT	Northbound THRU	Northbound LT	Eastbound RT	Eastbound THRU	Eastbound LT
1053	615	1	**Yes**	SR 20 EB Ramps	Idaho Maryland Rd	Y					621	50	315		300	165	217	
1159	820	2	**Yes**	SR 20 WB Ramps	Idaho Maryland Rd	Y	446	328	46	128	247	362	50	41	44	12	124	286
1058	328	3	**Yes**	Bennett Street	E. Main Street	Y	56	7	70	50	400	180	109	50	169	163	260	5
693	514	4	**Yes**	Bennett Street	SR 20 WB Ramp	N	196	297		141	208	165		187	13			
708	386	5	**Yes**	Bennett Street	SR 20 EB Ramp	N		275	187				127	119		2	303	81
417	151	6	**No**	WB Frontage	Bank Street	N	77	336	4		38	17				45	106	
344	110	7	**No**	EB Frontage	Bank Street	N				9	30		19	300	25		35	75
394	282	8	**No**	WB Frontage	Colfax Avenue	N	124	239	31		148	21					282	
249	315	9	**No**	EB Frontage	Colfax Avenue	N				76	239		75	168	6		209	100
782	486	10	**Yes**	S. Auburn Street	Neal Street	N	83	263	76	69	174			256	104	200	227	59
820	380	11	**Yes**	S. Auburn Street	WB Frontage	N	249	199			244	136		348	24			
735	287	12	**No**	S. Auburn Street	EB Frontage	N		336	5				163	231		44	86	157

Source: PRISM Engineering, NCTC, and City of Grass Valley

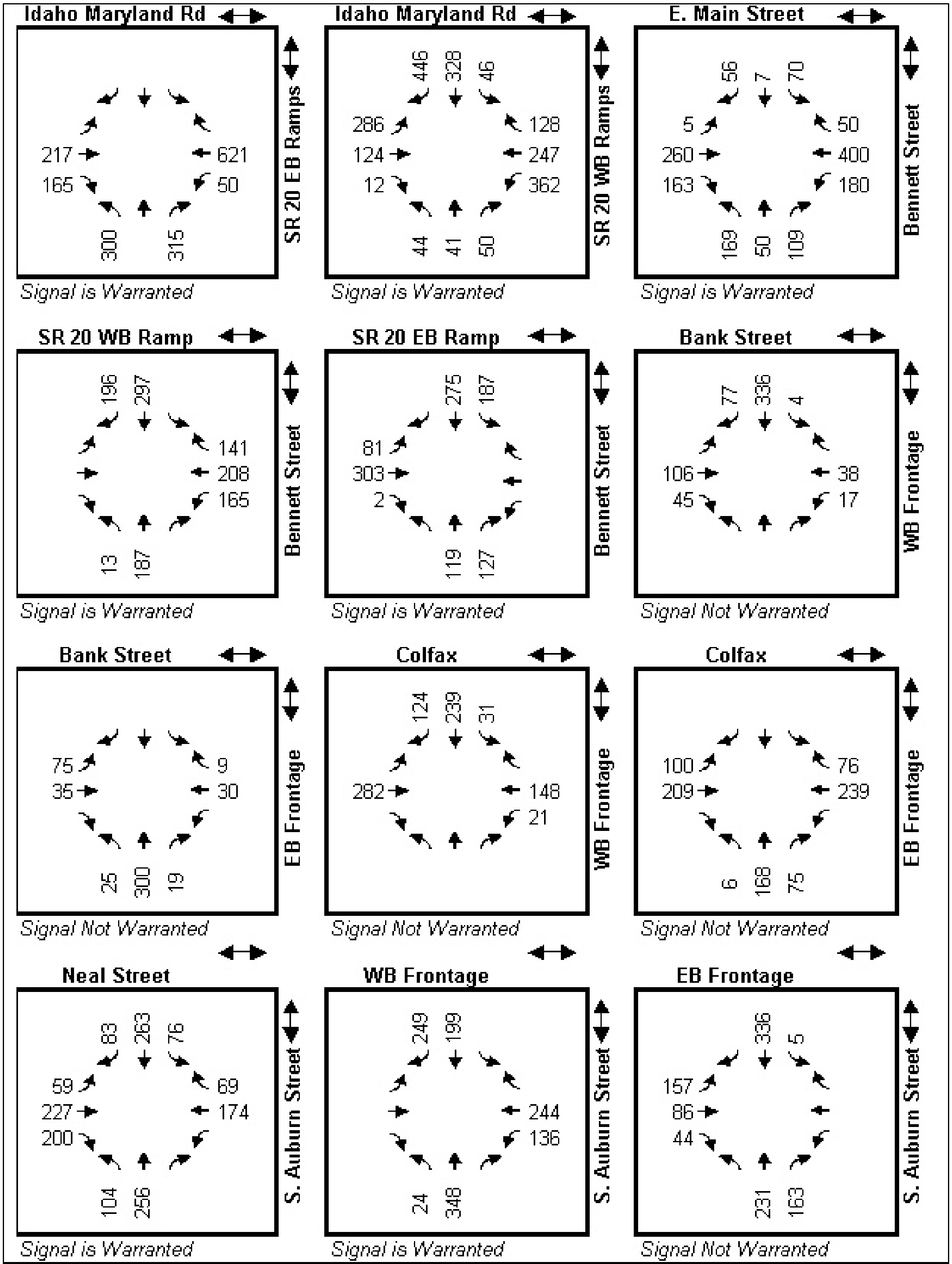


Figure 4 Year 2004 Peak Hour Turning Movement Volumes

TABLE 2
SIGNAL WARRANT AND PEAK HOUR VOLUMES SUMMARY*
FOR INTERIM CONDITIONS

Major Total VPH	Minor Total VPH		Signal Warr?	N/S Street	E/W Street	E-W MAJOR ST?	Southbound RT	Southbound THRU	Southbound LT	Westbound RT	Westbound THRU	Westbound LT	Northbound RT	Northbound THRU	Northbound LT	Eastbound RT	Eastbound THRU	Eastbound LT
1053	615	1	**Yes**	SR 20 EB Ramps	Idaho Maryland Rd	Y					621	50	315		300	165	217	
1159	820	2	**Yes**	SR 20 WB Ramps	Idaho Maryland Rd	Y	446	328	46	128	247	362	50	41	550	12	124	286
1572	328	3	**Yes**	Bennett Street	E. Main Street	Y	56	7	70	141	658	345	109	50	169	163	260	5
693		4	**No**	Bennett Street	SR 20 WB Ramp	N	196	297						187	13			
708	386	5	**Yes**	Bennett Street	SR 20 EB Ramp	N		275	187				127	119		2	303	81
417	151	6	**No**	WB Frontage	Bank Street	N	77	336	4		38	17				45	106	
344	110	7	**No**	EB Frontage	Bank Street	N				9	30		19	300	25		35	75
394	282	8	**No**	WB Frontage	Colfax Avenue	N	124	239	31		148	21					282	
249	315	9	**No**	EB Frontage	Colfax Avenue	N				76	239		75	168	6		209	100
782	486	10	**Yes**	S. Auburn Street	Neal Street	N	83	263	76	69	174			256	104	200	227	59
820	380	11	**Yes**	S. Auburn Street	WB Frontage	N	249	199			244	136		348	24			
735	287	12	**No**	S. Auburn Street	EB Frontage	N		336	5				163	231		44	86	157

Source: PRISM Engineering, NCTC, and City of Grass Valley

*The difference is that Bennett Street offramp traffic has been shifted to the Idaho Maryland / East Main intersection, and the Idaho Maryland onramp has a K-Rail force traffic onto the freeway and to close the Bennett Street offramp during the “INTERIM” conditions while the Bennett Street offramp is widened.

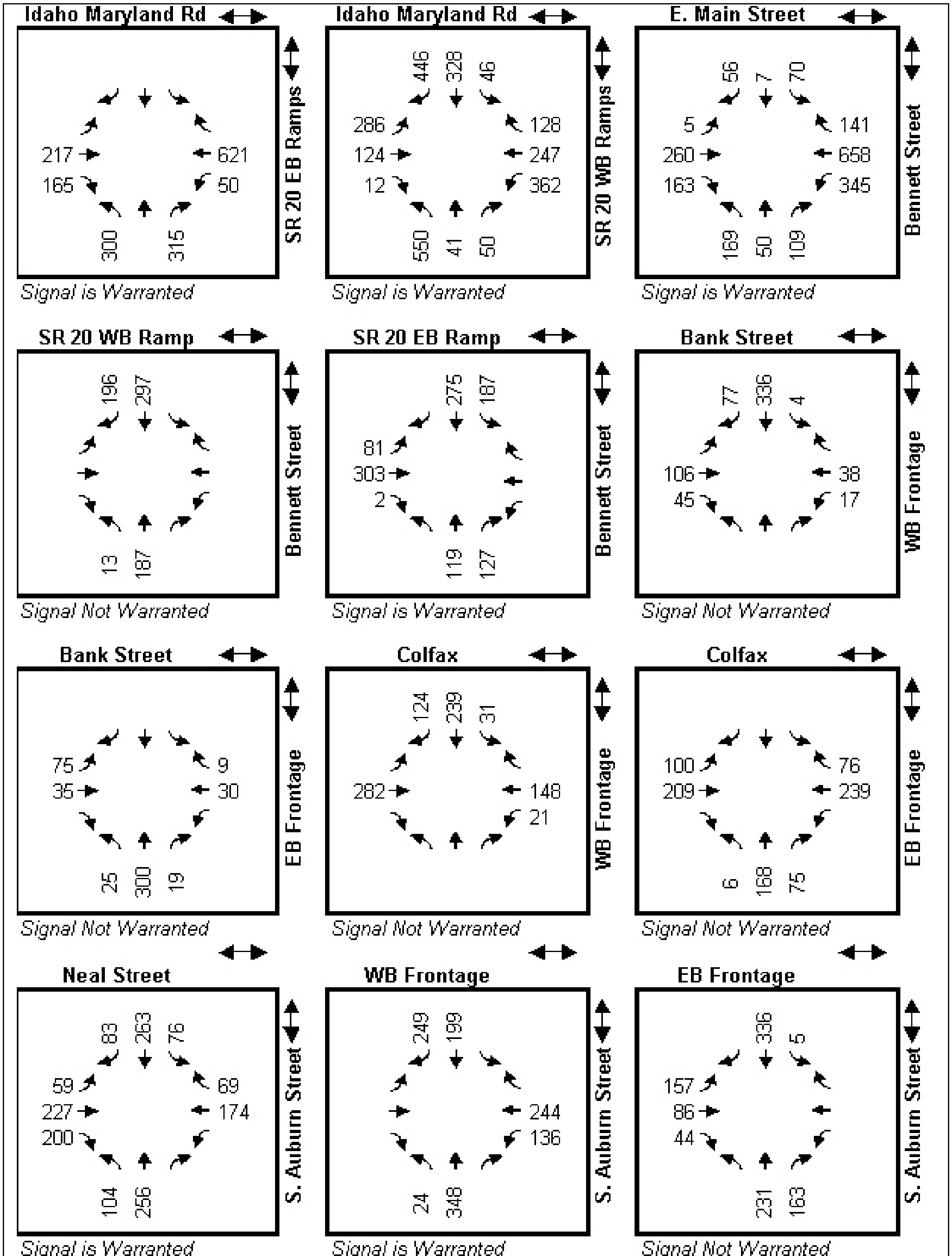


Figure 5 Interim Peak Hour Turning Movement Volumes

Origin / Destination Surveys

One of the purposes of this work was to determine the vehicles per minute (vpm) flow rate of traffic from the Idaho Maryland Intersection to the freeway on-ramp[1] and to compare that with the expected flow rate from a roundabout at this location. The hourly average flow rate to the onramp from a roundabout with a single lane approach on Idaho Maryland would be about the same as the existing stop sign controlled intersection, but the average flow from a roundabout with a two-lane approach on Idaho Maryland would be in the 14-16 vpm range. Detailed RODEL[2] analyses and associated calculations for various roundabout configurations at this intersection are given in the appendix.

As a part of this analysis it was determined that the weave would become a problem in the next few years. Caltrans suggested that if the Idaho Maryland On-ramp freeway weave were eliminated, it would be possible to construct improvements at the Idaho Maryland/East Main Intersection.

PRISM Engineering conducted a license plate survey to determine existing traffic patterns between the Idaho Maryland, Auburn Street and Empire Street ramps. License plate data was collected for each vehicle at the following consecutive freeway ramps:

1. Idaho Maryland Road SR 20/49 WB onramp
2. Auburn Street SR 20/49 WB onramp
3. Empire Street SR 20/49 WB offramp

The last three numbers of each license plate were written for each vehicle entering the respective ramp. The data was organized into five-minute intervals during the peak hour time period (4:15 to 5:15 pm). This data was then transcribed into a computer spreadsheet, and saved as a text file for post-processing in a computer program written by PRISM Engineering that found license plate matches between the three ramps. The summary of origin destination data is given in Table 3, and relates to traffic patterns during the pm peak hour time period.

A total of 138 vehicles were “tracked” via license plate survey from the Auburn Street on-ramp to the Empire Street off-ramp. Since 69 of these

[1] (which according to the data is approximately 12-13 vpm)
[2] RODEL is the software that calculates LOS for a modern roundabout using entry geometry details coupled with traffic volume.

vehicles came from the Idaho Maryland on-ramp, it can be deduced that the remaining 69 vehicles came from the downtown area as they entered the Auburn Street on-ramp, and continued on to the Empire Street off-ramp. In row two of the table, it means that 160 of the 631 (see appendix) vehicles that entered the freeway at the Idaho Maryland on-ramp got off at the Empire Street off-ramp.

Table 3
Origin Destination Data Summary

Origin Location	**Destination 1 Bennett Street Off-ramp (vph)**	**Destination 2 Auburn Street On-ramp (vph)**	**Destination 3 Empire Street Off-ramp (vph)**
Idaho Maryland On-ramp via Frontage Road	113	69	69
Idaho Maryland On-ramp via SR 20/49 Freeway	N/A	N/A	160
Auburn Street On-ramp at Colfax Triangle	N/A	N/A	138

Source: PRISM Engineering

Video Traffic Counts

Digital video cameras were set up at the same three locations to capture weaving traffic patterns, peak hour factors, traffic flows, and speeds. This video footage was entered into a computer and observed to determine traffic volumes and traffic conditions at the weave sections of the freeway, as well as at the Colfax/Auburn/Neal Street triangle of intersections. From the video it was apparent that there is a potential safety and capacity issue at the Idaho Maryland on-ramp SR 20/49 weave with the Bennett Street off-ramp traffic. In addition, the Colfax/Auburn/Neal Street triangle set of intersections shows a busy pattern of traffic with inefficiencies built into the existing design, and is the City of Grass Valley's highest accident location.

The video traffic counts were taken on Wednesday January 14, 2004, and post-processed by electronic counter board to ensure accuracy. It was determined by inspection that the video traffic counts only slightly varied from the Year 2002 Caltrans counts taken for the Dorsey Drive Interchange Project (EA 412400). The PRISM Engineering video counts were slightly higher in some cases, and slightly lower at other locations. The variance was anywhere from a +/-1% difference to a +/-15% difference, which is typical for traffic counts from day to day. This indicates that there has not been an appreciable difference in traffic volumes during the last year. The new traffic count data is summarized in the appendix.

The traffic count data was entered into the Synchro-Pro and Sim-Traffic micro-simulation software to examine traffic flows and patterns during peak hour demands. We utilized these software programs loaded with existing and future traffic volumes to determine the impacts that alternative traffic patterns would have on the system.

Existing Freeway Weave Analysis Comparison to Future

Freeway weaves were examined and analyzed on the SR 20/49 freeway from the Idaho Maryland Road on-ramp to the Empire Street off-ramp (a total of two Type A weave sections[3]). The HCM 2000 methodology found in Chapter 24 was used to analyze the two weave sections. The percent trucks on the Golden Center Freeway is approximately 7% in the study area. The grade of the freeway between Idaho Maryland Road and Empire Street is flat to rolling hills. Rolling hills was used in the calculations to be more conservative. The assumed free-flow speed used was 65 mph. These factors coupled with the existing peak hour volumes were used to calculate a level of service of LOS D for the Idaho Maryland/Bennett Street ramp weave, and LOS C for the Auburn/Empire Street weave. Table 4 shows the specific passenger car equivalent volumes (after grade and percent trucks are accounted for) and the corresponding levels of service for each ramp weave analyzed in the existing Year 2004 condition. Table 5 shows the Year 2027 condition.

The Idaho Maryland onramp will go to LOS E conditions when an increase of approximately 7% in the existing traffic volume takes place. Using the NCTC traffic model as a guide for growth rates, this will take place in 2 to 3 years, and LOS E conditions will exist on the ramp weave. LOS F conditions, or total breakdown is projected to take place with a 23% increase. The freeway mainline volume is projected (by the NCTC model) to increase 23% by the Year 2016. These projections indicate that an improvement will be needed in the near future.

[3] A Type A freeway weave is where traffic has to only change one lane to make the weave. This is typified by a two lane freeway section with an adjacent auxiliary lane, or a total of three lanes in the weave section being analyzed. The auxiliary lane is an on-ramp which extends to become the off-ramp .

Table 5 shows the conditions that are projected for the Idaho Maryland on-ramp – Bennett Street off-ramp weave section by the Year 2027.

Table 4
Freeway Weave HCM 2000 Analysis Summary, Year 2004

Bennett Weave Area Level of Service (LOS)	SR 20/49 Mainline Traffic (vph)	Mainline to Bennett (vph)	Idaho Maryland to Mainline (vph)	Idaho Maryland to Bennett (vph)
LOS D	1,210 increased* to **1,573**	420 increased* to **526**	631 increased* to **820**	113 increased* to **147**
Empire Weave Area Level of Service (LOS)	**SR 20/49 Mainline Traffic (vph)**	**Mainline to Empire (vph)**	**Auburn to Mainline (vph)**	**Auburn to Empire (vph)**
LOS C	1,057 increased* to **1,374**	702 increased* to **913**	362 increased* to **471**	138 increased* to **179**

**all trucks and cars converted (increased) to passenger car equivalent.*
Source: PRISM Engineering

Table 5
Freeway Weave HCM 2000 Analysis Summary, Year 2027

Bennett Weave Area Level of Service (LOS)	SR 20/49 Mainline Traffic (vph)	Mainline to Bennett (vph)	Idaho Maryland to Mainline (vph)	Idaho Maryland to Bennett (vph)
LOS F	1,706 increased* to **2,218**	592 increased* to **770**	890 increased* to **1,157**	159 increased* to **207**
Empire Weave Area Level of Service (LOS)	**SR 20/49 Mainline Traffic (vph)**	**Mainline to Empire (vph)**	**Auburn to Mainline (vph)**	**Auburn to Empire (vph)**
LOS D/E	1,442 increased* to **1,874**	957 increased* to **1,245**	494 increased* to **642**	188 increased* to **245**

**all trucks and cars converted (increased) to passenger car equivalent.*
Source: PRISM Engineering

Table 6 documents the Year 2000 Highway Capacity Manual's criteria for LOS at intersections. The middle column documents the number of seconds of delay at an unsignalized intersection that corresponds to each LOS ranking in the first column. The third column shows the LOS criteria for a signalized intersection.

Table 6

Delay Level of Service Criteria for Intersections

LOS	Unsignalized	Signalized
A	1-10 seconds	1-10 seconds
B	11-15 seconds	11-20 seconds
C	16-25 seconds	21-35 seconds
D	26-35 seconds	36-55 seconds
E	36-50 seconds	56-80 seconds
F	51+ seconds	81+ seconds

Source: PRISM Engineering, Synchro Pro, and HCM

Table 7 summarizes the results of the capacity analyses conducted for the existing conditions, as well as various scenarios of the preferred alternative including interim conditions, project complete, and year 2027 project complete. These analyses show that the project will work at LOS D or better conditions far into the future (Year 2027), and that the interim conditions will be acceptable (a significant improvement over existing conditions) until the project is complete. Comparing the first column with the second column shows that even with the interim condition where construction is taking place, the levels of service at the Idaho Maryland freeway ramps improve significantly over the existing LOS F conditions at these intersections. In addition, several other locations improve in LOS.

Table 7 Intersection Level of Service Analyses Summary
PM Peak Hour Scenarios

		EXISTING ONLY 2004		INTERIM 2004-2006		PROJECT COMPLETE 2004-2006		PROJECT COMPLETE 2027	
		P.M. Peak Hour		P.M. Peak Hour		P.M. Peak Hour		P.M. Peak Hour	
No.	Intersection Street Names	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
1	SR 20 EB Ramps at Idaho Maryland Rd	51+	F	21	C	21	C	24	C
2	SR 20 WB Ramps at Idaho Maryland Rd	51+	F	37*	D	15	B/C	50	D
3	Bennett Street at E. Main Street	27	D	26	C	34	C	33*	C/D
4	Bennett Street at SR 20 WB Ramp	26	D	1	A	29	C	34*	C/D
5	Bennett Street at SR 20 EB Ramp	15	B	15	B	31	C	34	C
6	Tinloy Street at Bank Street	9	A	8	A	26	D	25*	C
7	Hansen Avenue at Bank Street	9	A	9	A	10	A	14*	B
8	Tinloy Street at Colfax	13	B/E	12	B/E	28*	D	57*	E
9	Hansen Avenue at Colfax	12	B	12	B	11	B	18	C
10	S. Auburn Street at Neal Street	27	C/E	31	C/E	13	B	42*	D
11	S. Auburn Street at Tinloy Street	10	B/E	9	A	26	C	34*	C/D
12	S. Auburn Street at Hansen	17	C	18	C	14	B	44*	D

[1]Average delay per vehicle in seconds, based on HCM 2000 methodology

LOS = Level of service

2	unsignalized intersection
3	signalized intersection

**Delay from SimTraffic Micro-Simulation Reports*

Alternatives Analysis

Several alternatives were developed and examined in this study, and a preferred alternative evolved from numerous meetings with the City, Caltrans, the County and the NCTC. The development of the Grass Valley Street System Master Plan document (which included several public workshops and City Council hearings, and which has been finalized and approved by City Council on October 14, 2004) was the primary driving force behind the development of a preferred alternative from the City's standpoint.

This report examines all alternatives that lead up to the preferred alternative, which has been accepted politically by the City, and which also addresses the City's General Plan policy to achieve LOS D or better conditions throughout the City, and with all intersections interfacing with Caltrans freeway ramp facilities.

Caltrans Preliminary Studies

In recognition of the "weave" problem Caltrans has done preliminary investigation of various improvement concepts:

- Build a "flyover" bridge from the East Main Street intersection to connect to the Gold Center freeway, and build an additional auxiliary lane on the Golden Center freeway to receive the fly-over ramp traffic (this would require additional bridge expansion on the freeway to accommodate the new lane). Cost is estimated to be prohibitive.

- Force Idaho Maryland onramp traffic to use the Bennett Street offramp and the existing frontage road system to travel to Auburn Street onramp to gain access to the freeway. Cost is minimal in comparison.

This report focused on the SR 20/49 frontage road system to determine if the available capacity could be utilized as part of a "low cost" solution to the weave problem. The freeway ramp weaves were also re-analyzed to determine if the shift in traffic flows would adversely affect the freeway and ramp operations.

It was determined that the change in traffic patterns did not have a significant effect on the operations of the freeway. LOS C conditions would still exist at the Auburn/Empire ramp weave in the existing condition. In the shifting of Idaho Maryland traffic volumes to the frontage road system, there is a reduction in over 800 vehicles to the mainline freeway just before the Auburn/Empire ramp weave area.

The emphasis of the analysis and associated mitigations focused on the frontage road system, and more especially at the Colfax/Auburn/Neat Street triangle of intersections. This triad of intersections is one of Grass Valley's highest accident locations, and any increase in traffic to the existing street layout will not be acceptable. See Figure 1 for details of the existing road system under study, and the corresponding traffic volumes and levels of service.

NCTC Studies

In recognition of the Caltrans concerns relating to the installation of a traffic signal at the Idaho Maryland / East Main intersection / SR 20/49 WB ramps, the NCTC studied a modern roundabout installation alternative at this location. The roundabout would mitigate any concerns that Caltrans had concerning platoons of traffic, as the roundabout would “meter” vehicle entry onto the freeway. It would also mitigate the LOS F conditions at the intersection to LOS B conditions. Several alternatives of roundabout designs were developed to vary impact to surrounding property owners at the intersection frontage. The roundabout solution was eventually ruled out because it also was not able to address mitigation of the freeway weave problem now existing on SR 20/49 in the westbound direction at the Bennett Street offramp, and had the additional effect of adversely impacting adjacent properties.

As a result of the continued weave problem, and the inability of the local community to mitigate with grade separation construction (the flyover concept envisioned by Caltrans), the NCTC embarked upon a much less costly solution to examine a frontage road improvement concept that would divert Idaho Maryland onramp traffic to the Bennett Street offramp and the existing frontage road system to travel to Auburn Street onramp to gain access to the freeway. The cost for this improvement while substantial (estimated at approximately $6 million dollars), is much less than the Caltrans mitigation concept to construct grade separations (bridges) and to widen the SR 20/49 freeway (including the Bennett Street bridge, the Bank Street bridge, and the Colfax/Auburn Street bridge).

This report focused on the SR 20/49 frontage road system to determine if the available capacity could be utilized as part of a "low cost" solution to the weave problem. The freeway ramp weaves were also re-analyzed to determine if the shift in traffic flows would adversely affect the freeway and ramp operations.

It was determined that the change in traffic patterns did not have a negative impact to operations of the freeway mainline traffic. LOS C conditions would still exist at the Auburn/Empire ramp weave in the existing condition, and after the change in traffic patterns. In the shifting of Idaho Maryland traffic volumes to the frontage road system, there is a reduction in over 800 vehicles to the mainline freeway just before the Auburn/Empire ramp weave area.

The emphasis of the analysis and associated mitigations focused on the frontage road system, and more especially at the Colfax/Auburn/Neat Street triangle of intersections. This triad of intersections is one of Grass Valley's highest accident locations, and any increase in traffic to the existing street layout will cause LOS to drop to an unacceptable level. See Figure 1 for details of the existing road system under study, and the corresponding traffic volumes and levels of service.

NCTC Frontage Road Preliminary Alternatives

Several alternatives were initially developed to mitigate existing traffic deficiencies in the frontage road corridor to enhance local circulation. These alternatives focused initially on the area consisting of the closely spaced triad of intersections including:

1. Realign many of the local streets to meet into one larger intersection, leaving the frontage road alignment in place so that traffic from the Idaho Maryland ramp can have a higher efficiency in getting onto the freeway. This can be done without interference to the freeway bridge piers, and a single signal would control the one new intersection. A side benefit is expanding the existing park and ride area by eliminating one lane of the frontage road on the east side. See Figure 6 for details of this concept.
2. Completely modify the internal road system to convert it to a single modern roundabout. This large roundabout would have high capacity and be able to handle the increase in traffic, and can be physically accommodated between the existing freeway bridge piers. This

concept differs from previous concepts developed for the area in that Auburn Street southbound traffic is forced to turn right at Neal Street. See Figure 7 for this concept.

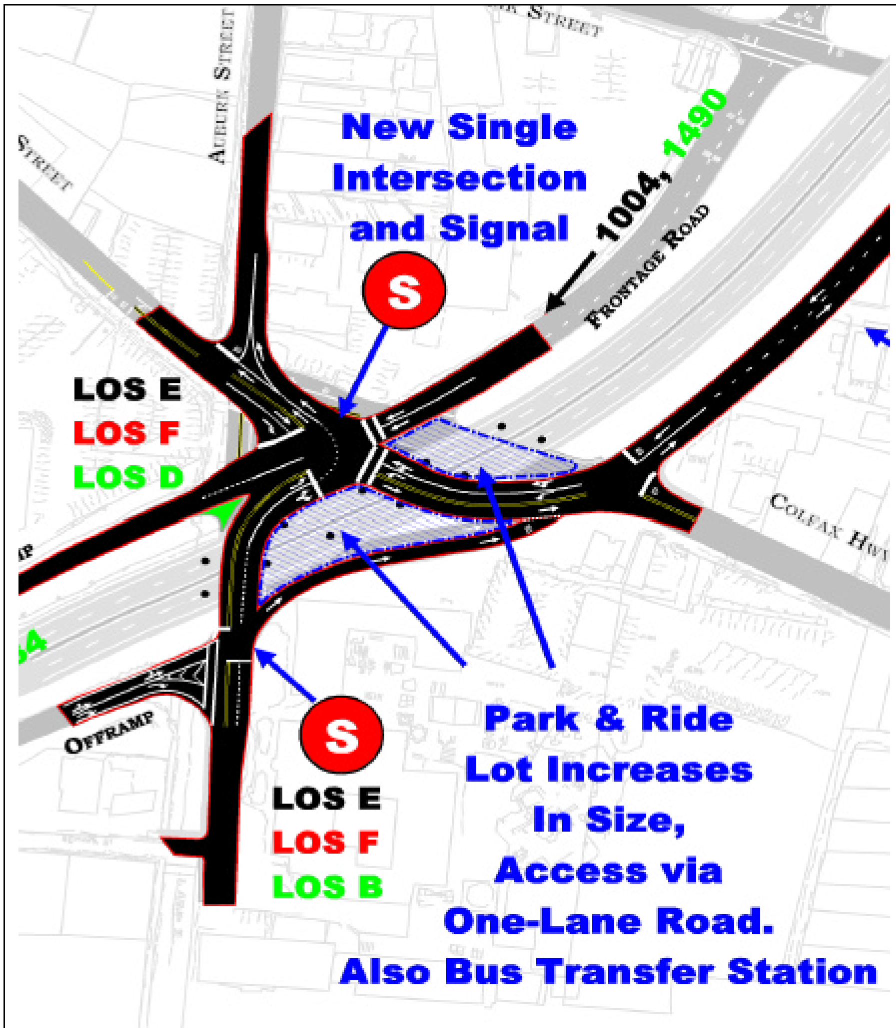
3. Convert existing streets to one-way streets in the counter-clockwise direction, so that the triangle essentially becomes a one-way loop. See Figure 8 for details of this concept. Stop sign control would handle initial traffic control for the area.

These three intersections are currently spaced at 90 feet apart from each other, in a triangle shape, and do not operate satisfactorily (LOS E conditions for Year 2004). The sharp angles at the intersections also contribute to an abnormally high accident rate at these intersections.

The alternatives included a “Single Intersection” concept (see Figure 6 for details), a “Modern Roundabout” concept (see Figure 7 for details), and a “one-way loop” concept (see Figure 8 for details).

Either one of these alternatives will provide immediate relief to existing traffic patterns through the triad of intersections because these changes will provide additional capacity. Only the first alternative will provide enough additional capacity to handle the shifting in Idaho Maryland on-ramp traffic, as well as future growth traffic. The roundabout has sight distance challenges with the travel path through the freeway bridge support piers. The one-way loop alternative is more limited in capacity due to short storage lengths between the existing signalized intersections. The changing to one-way streets helps reduce turning conflicts and increase capacity, but it is still limited by storage distances. Therefore the best alternative from a traffic engineering standpoint of capacity and circulation is the single intersection alternative, with the modern roundabout alternative coming in second, and the one-way loop alternative a distant third.

Signals are currently installed at Neal/Auburn, Colfax/Frontage, and Auburn/on-ramp intersections. This alternative eliminates three intersections, and channels all traffic into one intersection. All previous travel paths are supported. It has increased efficiency for traffic from off-ramp with new signal. It can move high volumes of traffic along frontage road to freeway with priority signal timing. A dual left turn lane into Auburn Street downtown moves traffic efficiently. The Caltrans park and ride lot area would be increased in size through elimination of one lane of frontage road.

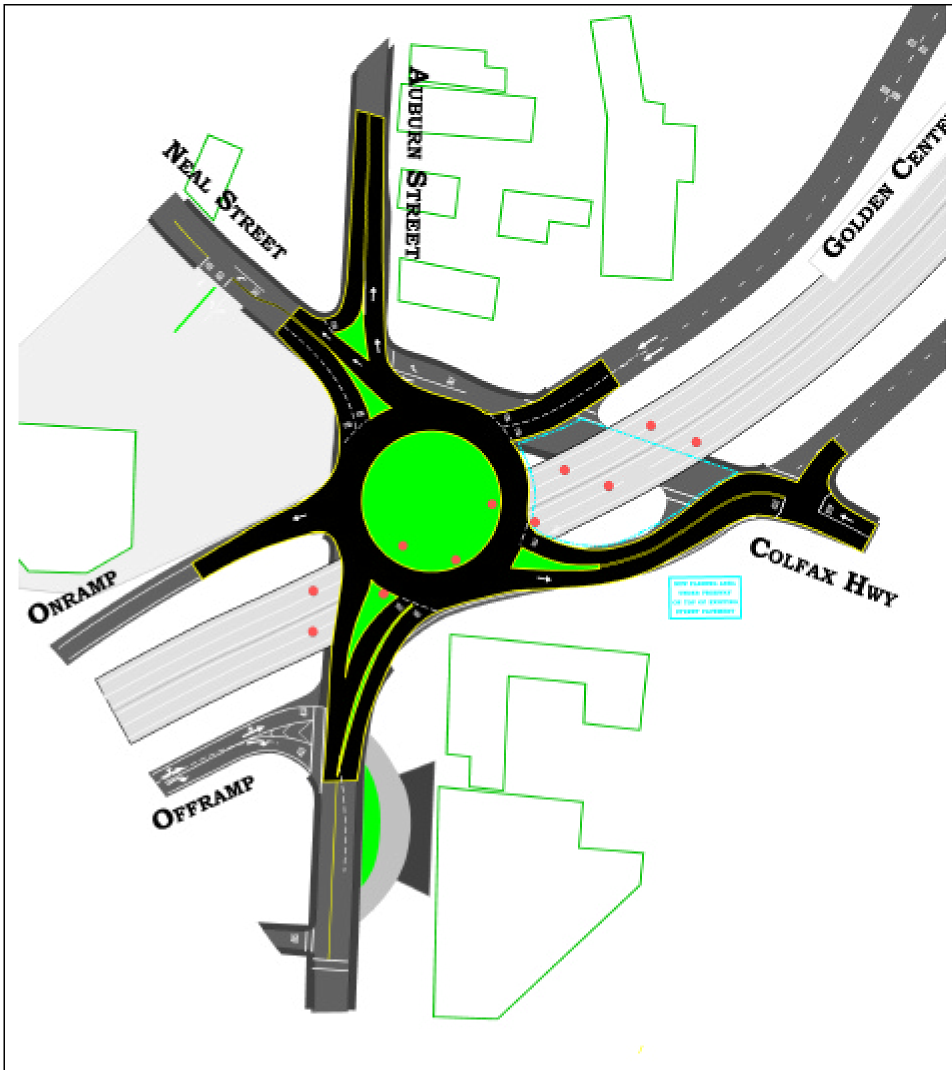


Realign many of the local streets to meet into one larger intersection, leaving the frontage road alignment in place so that traffic from the Idaho Maryland ramp can have a higher efficiency in getting onto the freeway. This can be done without interference to the freeway bridge piers, and a single signal would control the one new intersection. A side benefit is expanding the existing park and ride area by eliminating one lane of the frontage road on the east side.

(note: black dots in freeway lanes represent support columns under bridge)

Figure 6 Single Intersection Alternative

The mitigation concept shown in Figure 7 can help to eliminate many of the existing capacity constraints in the downtown area, and provide a gateway to and from the freeway system for existing conditions. However, it is limited in capacity for longer term solutions, or to provide additional capacity needed for say, sending more traffic down the frontage road to eliminate the hazardous weave on SR 20/49 at the Idaho Maryland/Bennett Street ramps. A plus is that traffic entering the roundabout from the offramp only have to cross one lane of traffic, helping keep ramp traffic moving. Some negatives include the fact that the park and ride lot size is reduced.



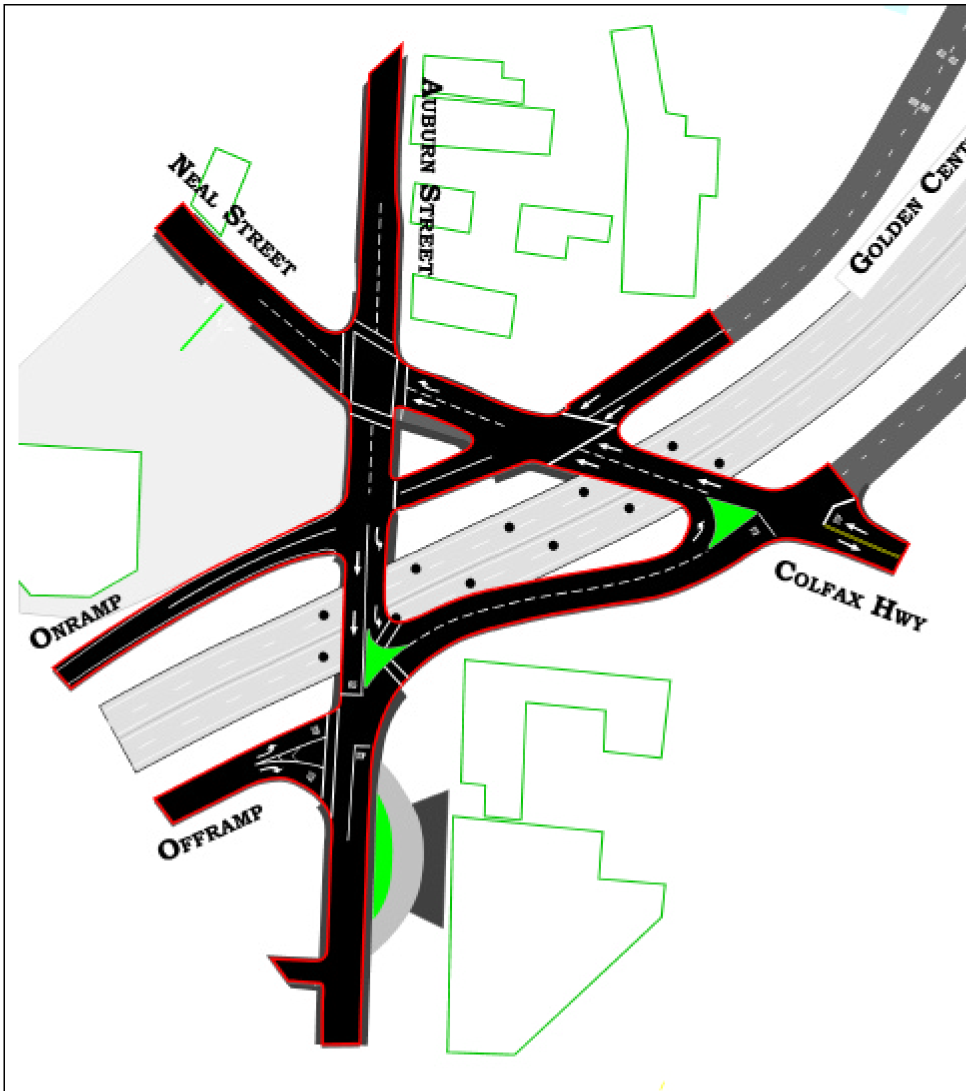
Completely modify the internal road system to convert it to a single modern roundabout. This large roundabout would have high capacity and be able to handle the increase in traffic, and can be physically accommodated between the existing freeway bridge piers. This concept differs from previous concepts developed for the area in that Auburn Street southbound traffic is forced to turn right at Neal Street.

(note: red dots in freeway lanes represent support columns under bridge)

Figure 7 Modern Roundabout Alternative

Sight distance is somewhat limited due to freeway bridge pier proximity to roundabout path, however, speeds are slow. The roundabout will fail on frontage road entrance due to high volumes with shifting of Idaho Maryland onramp traffic.

The alternative shown in Figure 8 helps to eliminate many of the turning conflicts and associated lane storage needs, but continues to use the existing three traffic signals (modified to work only with the one-way movements).



Convert existing streets to one-way streets in the counter-clockwise direction, so that the triangle essentially becomes a one-way loop. Stop sign control would handle initial traffic control for the area.

(note: black dots in freeway lanes represent support columns under bridge)

Figure 8 One-Way Loop Alternative

It is limited in capacity to handle any future traffic volumes, or to handle the additional proposed traffic flows on the frontage road (traffic diverted from the Idaho Maryland onramp). It will reduce accidents by virtue of eliminating many conflicts. It will fail with the additional proposed frontage road traffic volumes.

Preferred Alternative

Through the development of various improvement alternatives for the Idaho Maryland / SR 20/49 WB Onramp intersection, it was realized that a solution to the LOS F conditions at this intersection was larger than just the mitigation of the single intersection. In fact, the solution would depend on mitigation of a system of intersections to achieve the desired LOS at all study intersections. Idaho Maryland at East Main Street is in intersection that is tied together by traffic operations spanning several intersections throughout downtown Grass Valley. It is not possible to mitigate the intersection of Idaho Maryland Road at East Main Street (at the westbound SR 20/49 ramps) without negatively impacting either the freeway weave or another intersection such as the Bennett Street / SR 20/49 offramp, as well other intersections along the WB Frontage Road to the west. These are all inter-related in traffic operations and work as a system. As a result, the alternative concepts shown in Figure 6, 7, and 8 were modified and adjusted through the public review processes and political approval processes (in the development of the Grass Valley Street System Master Plan, approved by City Council on October 14, 2004), until they evolved into a comprehensive project described by Figures 9 and 10.

These figures show the staged development of the Grass Valley Corridor Improvement Project which is broken down into four stages or areas:

1. Traffic signals installed at the Idaho-Maryland/SR 20 eastbound on- and off-ramps (LOS E), and Idaho-Maryland/East Main Street (LOS F) intersection. This will improve the LOS of both intersections to “C”
2. Widening of the Bennett Street off-ramp and installation of a median barrier will eliminate the 300 foot weave (LOS D), where vehicles entering and leaving the freeway cross paths. Traffic accessing the freeway from the Idaho-Maryland/East Main intersection will be diverted along the frontage road (Tinloy Street) through a set of coordinated signals and enter the freeway via the on-ramp at South Auburn Street.
3. Traffic signals installed at the East Main/Bennett Street intersection (currently under construction), Bennett/SR20 off-ramp (Tinloy Street), and Bennett/SR 20 on-ramp (Hansen Way) intersections. The LOS of the Bennett/SR 20 ramp intersections will improve to “C” and the East Main/Bennett Street intersection will remain at “C”.

4. Move Neal Street to intersect with South Auburn Street approximately 50 feet north of the existing intersection. This increased distance will facilitate improved signal operations between the intersections at Neal Street, the SR 20 on-ramp (Tinloy Street), and the SR 20 off-ramp (Hansen Way). The resulting LOS at the intersections will improve to "B", "C", and "C" respectively in the short term, and LOS D by the Year 2027.

The resulting levels of service are shown on Figure 10 for the existing and future years, as well as in Table 7.

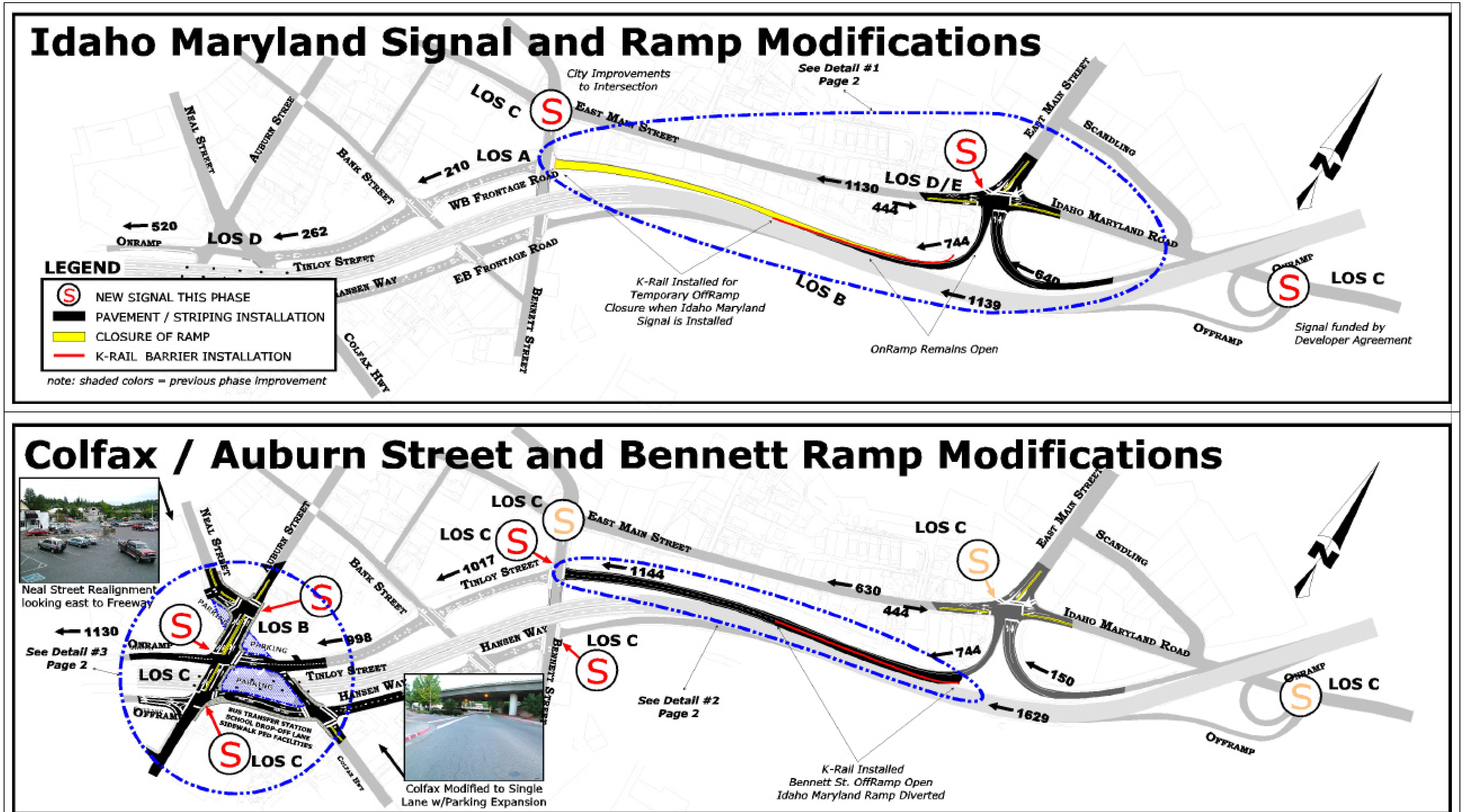
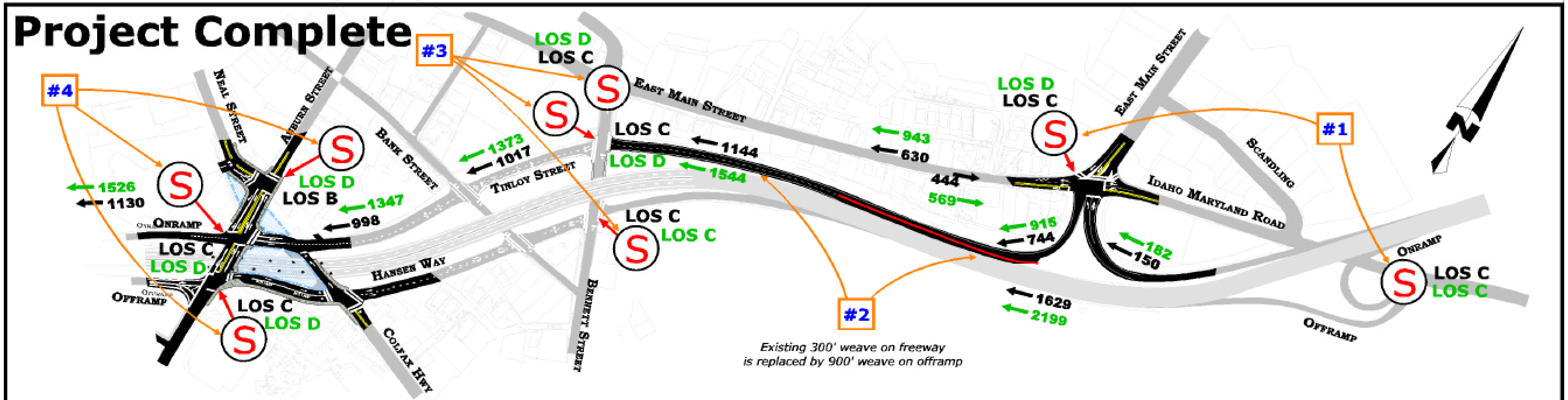


Figure 9 Staged Development of Preferred Alternative, (Part 1 of 2)



LEGEND

#1 Traffic signals installed at the Idaho-Maryland/SR 20 eastbound on- and off-ramps (LOS E), and Idaho-Maryland/East Main Street (LOS F) intersection. This will improve the LOS of both intersections to "C".

#2 Widening of the Bennett Street off-ramp and installation of a median barrier will eliminate the 300 foot weave (LOS D), where vehicles entering and leaving the freeway cross paths. Traffic accessing the freeway from the Idaho-Maryland/East Main intersection will be diverted along the frontage road (Tinloy Street) through a set of coordinated signals and enter the freeway via the on-ramp at South Auburn Street.

#3 Traffic signals installed at the East Main/Bennett Street intersection (currently under construction), Bennett/SR20 off-ramp (Tinloy Street), and Bennett/SR 20 on-ramp (Hansen Way) intersections. The LOS of the Bennett/SR 20 ramp intersections will improve to "C" and the East Main/Bennett Street intersection will remain at "C".

#4 Move Neal Street to intersect with South Auburn Street approximately 50 feet north of the existing intersection. This increased distance will facilitate improved signal operations between the intersections at Neal Street, the SR 20 on-ramp (Tinloy Street), and the SR 20 off-ramp (Hansen Way). The resulting LOS at the intersections will improve to "B", "C", and "C" respectively.

Year 2004 Level of Service	**LOS C**
Year 2004 PM Peak Volume	← **1144**
Year 2027 Level of Service	**LOS D**
Year 2027 PM Peak Volume	← **1144**

Prepared by: PRISM ENGINEERING

Figure 10 Staged Development of Preferred Alternative, (Part 2 of 2)

APPENDIX

Idaho Maryland Roundabout Analyses

Existing Conditions, PM Peak Hour

A new traffic count was taken at this intersection on August 28, 2002 from 4:00-6:00 pm. Traffic was counted electronically with 5 minute intervals, and the peak hour was determined to be between 4:15 and 5:15 pm. The total volume of traffic entering the intersection for the hour was 2,193 vehicles per hour. LOS E conditions currently exist overall at the intersection of Idaho Maryland Road and East Main Street at the SR 20/49 WB ramps. This intersection is controlled by a four-way stop sign configuration.

Observations made during the count revealed that each of the four approaches completely cleared all vehicle queues several times during the count, indicating that a "total demand" situation does not exist at this intersection, let alone for any one approach. The intersection is therefore not at capacity, and based on visual inspection, is not near capacity. The peak time periods where vehicle queues were sustained at 10 or more vehicles, lasted approximately 30 to 40 minutes. In other words, this intersection could move a significantly larger amount of traffic if the demand were constant and extant over any one hour period. The time to clear a long vehicle queue when all other approaches were fairly clear was about a minute. The recent count conducted on August 28, 2002 was very similar in volume to previous traffic study counts (slightly higher this time). A graph of this count is shown in Figure A1.

Two of the intersection approaches suffer from very poor levels of service (LOS F on the WB and SB approaches) during the p.m. peak hour time period. Figure A2 shows various photographs documenting the geometric conditions at the intersection.

A traffic signal installation at this location would significantly mitigate the poor levels of service from LOS E to LOS B conditions. However, a signal mitigation at this location is not acceptable to Caltrans due to the potential ramifications to freeway operations if large platoons of traffic are sent to the onramp and weave area of SR 20/49. The existing stop sign control helps to meter traffic from significantly impacting this potential problem. One car enters the ramp at a time, but a signal would allow a closely spaced platoon of vehicles to bombard the freeway mainline traffic flow, creating a significant slowing and breakdown of level of service on the freeway.

A modern roundabout, however, would help to continue the metering of traffic flow entering the freeway. Figure A3 shows the proposed modern roundabout for this intersection that would replace the existing stop sign control. The modern roundabout would have slightly better capacity and level of service than a new traffic signal. LOS A conditions would exist in the future with the proposed roundabout shown in Figure A3, while a signal would yield LOS B conditions.

A SynchroPro and SimTraffic traffic simulation model was developed specifically for this study to examine the traffic operations of the subject intersection, as well as the street and freeway system adjacent to it. Year 2002 and Year 2020 volumes (without the Dorsey interchange) were developed and assigned to the roadways. The simulation models were set up in a variety of different scenarios to examine traffic conditions for stop sign control, signal control, additional lanes, and the Bennett Street / East Main Street intersection modification (extension of Richardson Street).

Through trial and error, a modern roundabout solution was found to be the best solution that would not adversely impact the freeway mainline traffic flow operation.

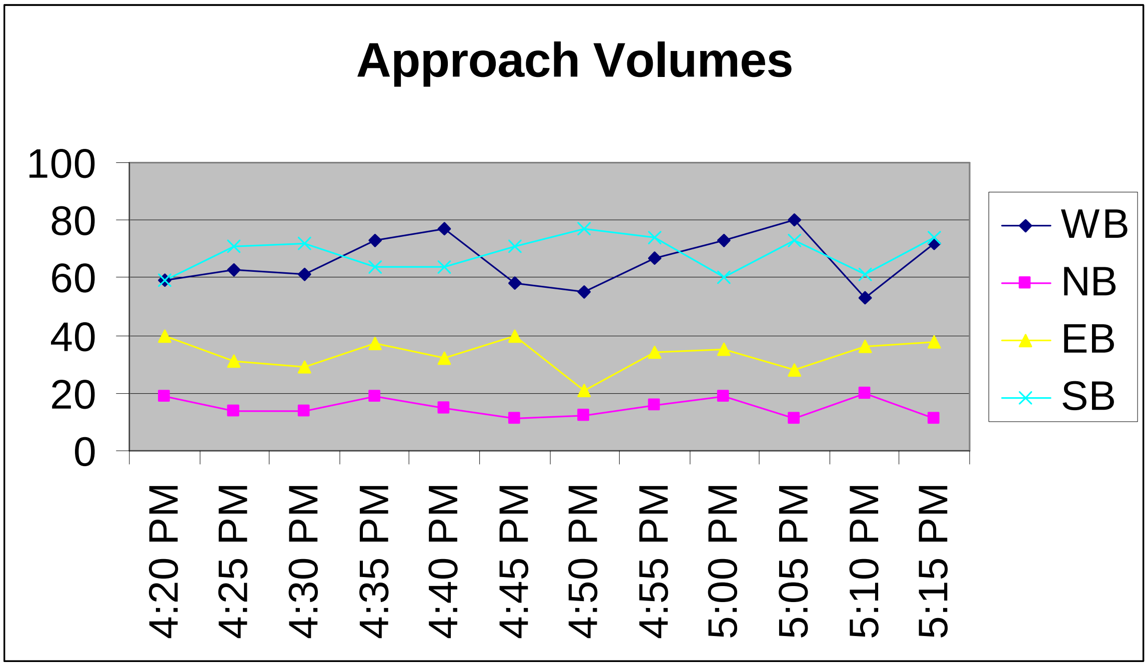


Figure A1 Existing Traffic Count Profile for PM Peak Hour

SR 20/49 Freeway Weave (westbound)

Looking south at SR 20/49 Ramps

E. Main Street Looking South

E. Main Street Looking East

Looking South at Gas Station

Looking East at Idaho Maryland Road

Figure A2 Intersection and Street Segment Photos

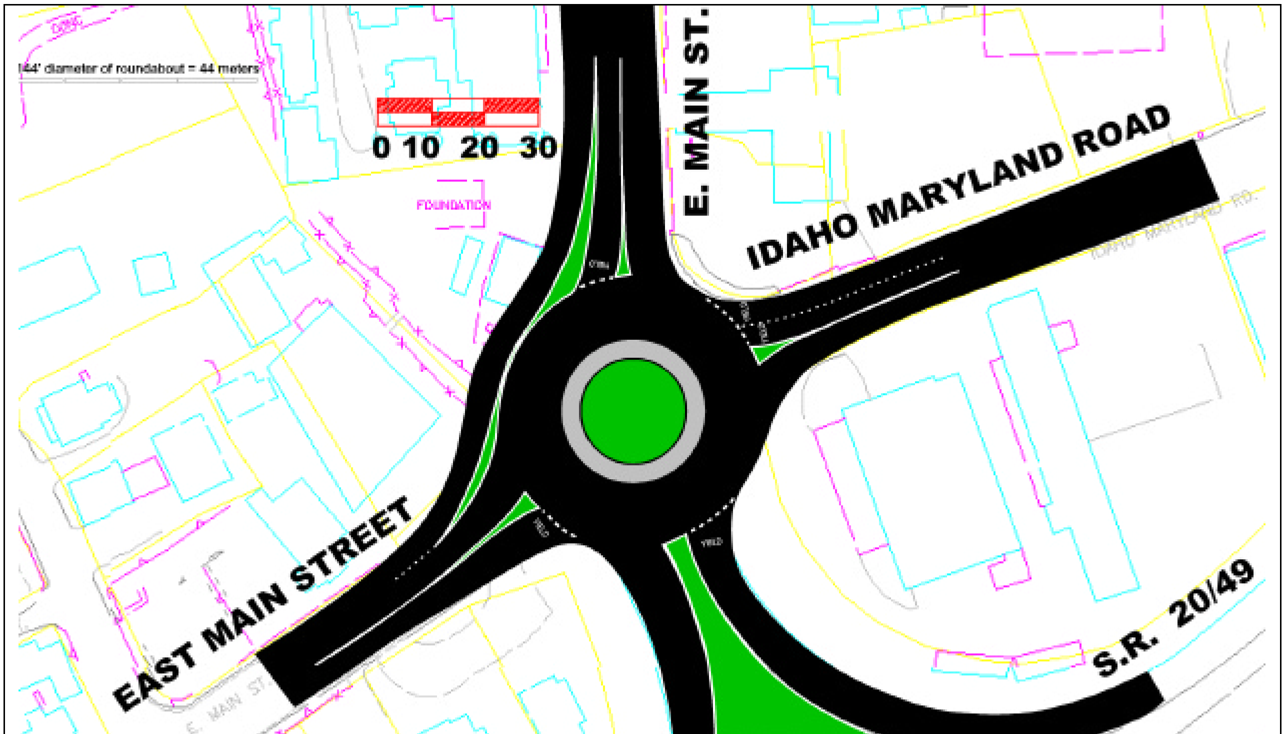


Figure A3 Proposed Modern Roundabout with SBR Bypass

As can be seen from Figure A3, the southbound right turn of East Main Street traffic is channeled through a bypass lane so that this large volume of traffic (408 vehicles per hour (vph) in Year 2002) does not impact the operation of the modern roundabout. This traffic merges gradually with westbound East Main Street traffic at a point past the roundabout. Traffic on east Main Street will have the right-of-way, and the bypass lane will yield to East Main Street westbound traffic. This may cause this bypass lane to queue slightly, but this will not affect the adequate operation of the modern roundabout internal traffic flow, as long as the lane is forced to yield to East Main Street traffic.

In an effort to minimize the impact to adjacent parcels, an a modification to the proposed roundabout shown in Figure A4 was developed. This alternative would eliminate the ideal “bypass lane” and prevent some of the impact to local parcels on the west side of the intersection (see next section for details), but not all.

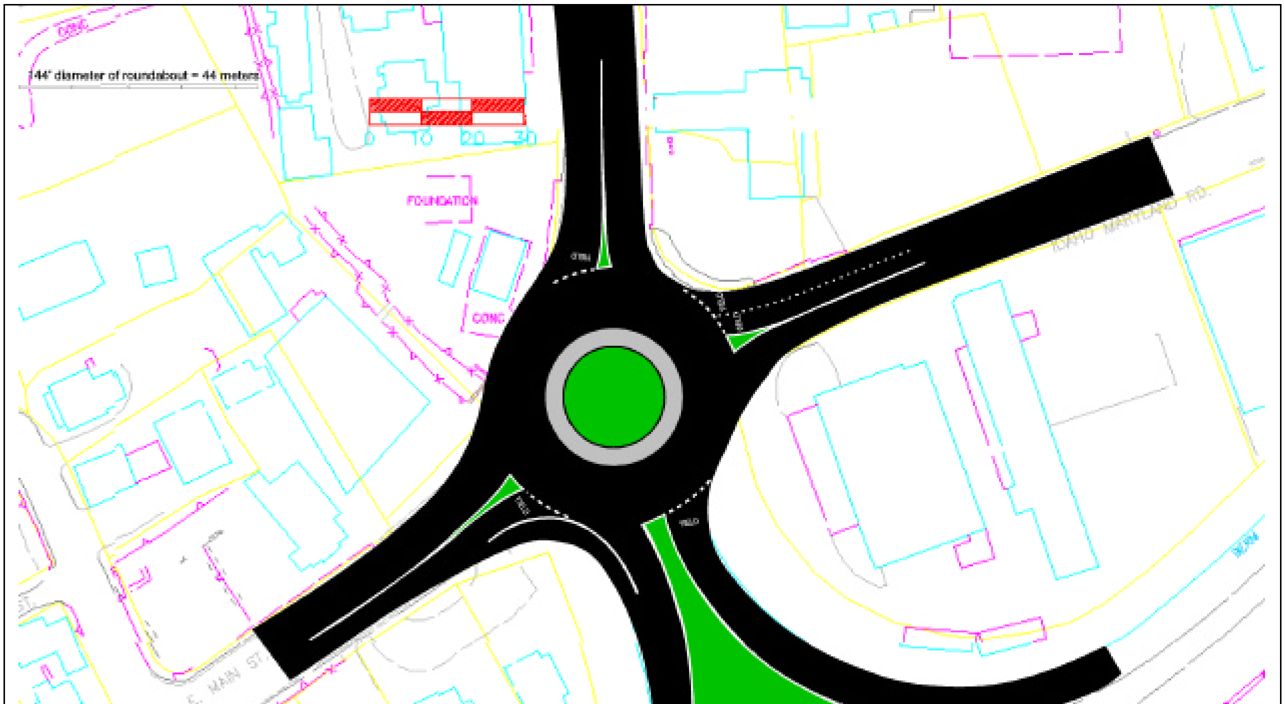


Figure A4 Alternative Modern Roundabout *without* SBR Bypass

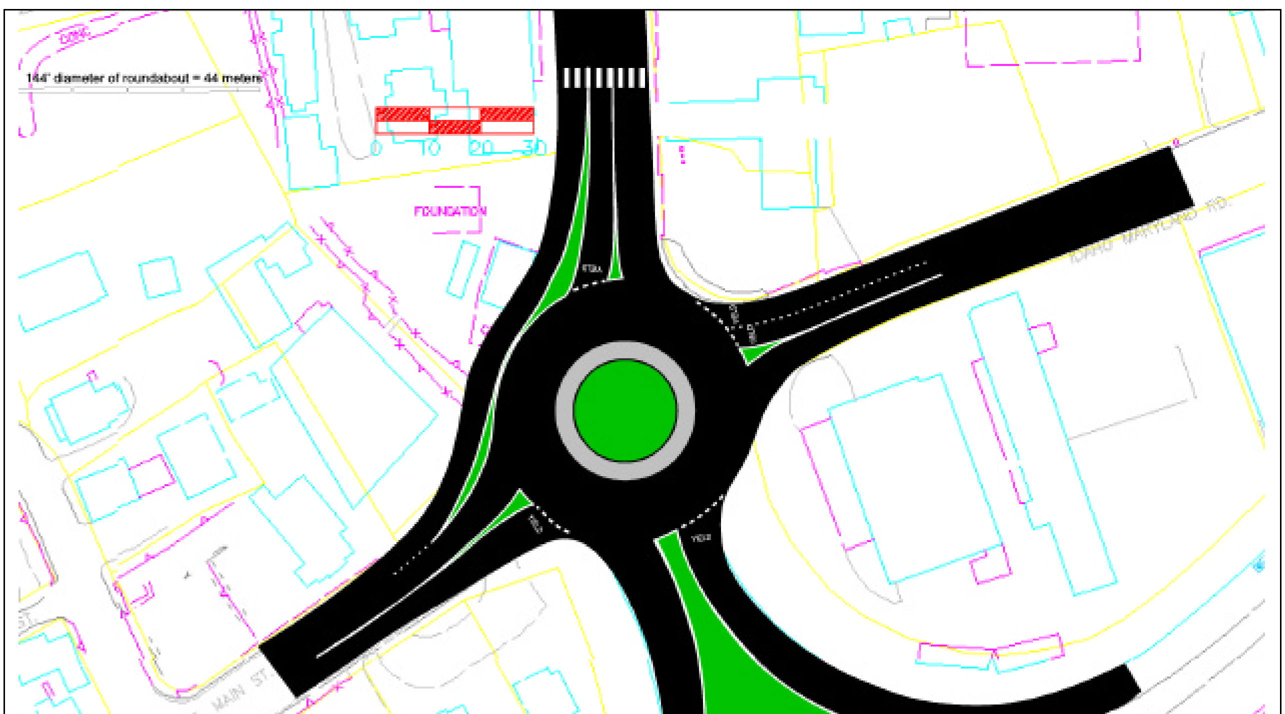


Figure A5 Modern Roundabout with a Cross Walk (not warranted)

Figure A4 shows a modern roundabout which has the same 150 foot diameter, but lacks the bypass lane for southbound East Main Street traffic. Even still, there is some impact to adjacent parcels which can not be avoided.

The problem with this configuration is that over 400 more vehicles per hour are forced to go through the roundabout in conflict with the traffic that is already there. The HCM analysis puts the approach V/C ratio at 1.04, or LOS F conditions. If the bypass lane is installed, this V/C ratio goes to 0.79 or LOS C/D conditions. Since the HCM 2000 methodology for roundabout level of service calculation is based on one lane roundabouts and one lane approaches, it does not give the additional benefit to more capacity gained from wider diameter circles, and two lane approaches (designed to move more traffic). LOS B/C conditions can be expected, and this has been verified with traffic simulations. The HCM as well as the Sidra software packages for roundabouts base their calculations on "gap acceptance" theory (the probability of a driver entering the roundabout based on a certain "gap" in traffic), but do not take into account the empirical data which has been assembled in software packages such as Arcady and Rodel. These packages take into account the specific measured roundabout capacity based on physical geometry. When the geometry of the roundabout circle, dimensions, etc., is taken into consideration, it has been shown that additional capacity can be gained (such as with a two or three lane approach, the specific angle of entry, the circle diameter, as well as the upstream width of the approach, etc.).

Figure A5 shows the same roundabout depicted in Figure A3, but with a cross walk location suggested for the north leg only. Cross walks are not typically installed unless there is at least 50 pedestrians per hour, and the traffic counts indicate that there is approximately 5 or less pedestrians per hour in this area. The pedestrians were observed on the north side of East Main Street, and not on the freeway side (south side). This is why if a cross walk is intalled by the City, that it should be on the north leg. It is not recommended that the cross walk be installed at the intersection due to the potential for vehicles exiting the north leg to stop inside the roundabout itself, causing a complete breakdown of roundabout operations. Ideally, mid-block crosswalks should be a minimum of 135 meters from a signalized intersection, and the cross walk shown in Figure A5 is only about 35 meters away (in order to make the cross walk "close enough" to the intersection so that pedestrians might use it). Since the pedestrian conflict in this area is low, the vehicle conflicts will be minimal, and the proximity of the cross walk is not anticipated to cause any delay to the roundabout operation, or to reduce its capacity by causing delay.

Capacity Calculations with Rodel Software

When the Rodel software package is used to analyze the specific roundabout geometric configurations, a more realistic level of service can be determined based on actual lane geometry, roundabout diameter, approach angle, approach width, etc.

The specific information relating to the proposed roundabouts shown in Figures A3 and A4 were entered into the Rodel software package for the Years 2002 and 2020 traffic volumes. The results of the analysis yielded LOS A conditions for Year 2002 conditions, and LOS B for Year 2020.

Table 1
Rodel Capacity Calculation for Modern Roundabout Alternatives

30:8:02 IDAHOM2002NEW SCHEME NAME 14

E	(m)	7.00	10.00	6.00	5.00
L'	(m)	20.00	10.00	10.00	10.00
V	(m)	6.00	5.00	5.00	5.00
RAD	(m)	20.00	20.00	20.00	20.00
PHI	(d)	30.00	30.00	30.00	30.00
DIA	(m)	50.00	50.00	50.00	50.00
GRAD SEP		0	0	0	0

TIME PERIOD	min	90
TIME SLICE	min	15
RESULTS PERIOD	min	15 75
TIME COST	$/min	15.00
FLOW PERIOD	min	15 75
FLOW TYPE	pcu/veh	VEH
FLOW PEAK	am/op/pm	PM

LEG NAME	PCU	FLOWS (1st exit 2nd etc...U)				FLOF	CL	FLOW RATIO	FLOW TIME
SR20RMP NB	1.05	75	57	49	0	1.00	50	0.75 1.125 0.75	15 45 75
IDAHOM WB	1.05	182	258	351	0	1.00	50	0.75 1.125 0.75	15 45 75
EMAIN SB	1.05	0	328	46	0	1.00	50	0.75 1.125 0.75	15 45 75
EMAIN EB	1.05	6	95	300	0	1.00	50	0.75 1.125 0.75	15 45 75

MODE 2

FLOW	veh	181	791	374	401
CAPACITY	veh	1680	1720	1256	1027
AVE DELAY	mins	0.04	0.06	0.07	0.10
MAX DELAY	mins	0.05	0.09	0.09	0.13
AVE QUEUE	veh	0	1	0	1
MAX QUEUE	veh	0	1	1	1

AVDEL s	4.2
L O S	A
VEH HRS	2.0
COST $	1817.2

F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc

Year 2002 volumes with Bypass
LOS A with 4.2 secs average delay

```
 6:6:02              IDAHOM2020ALT SCHEME NAME                        14
 E     (m)    7.00  10.00   6.00   5.00          TIME PERIOD     min      90
 L'    (m)   20.00  10.00  10.00  10.00          TIME SLICE      min      15
 V     (m)    6.00   5.00   5.00   5.00          RESULTS PERIOD min  15 75
 RAD   (m)   20.00  20.00  20.00  20.00          TIME COST     $/min  15.00
 PHI   (d)   30.00  30.00  30.00  30.00          FLOW PERIOD     min  15 75
 DIA   (m)   50.00  50.00  50.00  50.00          FLOW TYPE  pcu/veh    VEH
 GRAD SEP        0      0      0      0          FLOW PEAK am/op/pm     PM

 LEG NAME  PCU  FLOWS (1st exit 2nd etc...U) FLOF CL   FLOW RATIO    FLOW TIME
SR20RMP NB 1.05   55   51   63  0            1.00 50 0.75 1.125 0.75 15 45 75
IDAHOM WB  1.05  160  309  453  0            1.00 50 0.75 1.125 0.75 15 45 75
EMAIN SB   1.05  510  380   56  0            1.00 50 0.75 1.125 0.75 15 45 75
EMAIN EB   1.05   15  231  358  0            1.00 50 0.75 1.125 0.75 15 45 75

                               MODE 2
 FLOW        veh      169    922    946    604
 CAPACITY    veh     1542   1675   1153    933            AVDEL s     13.5
 AVE DELAY  mins     0.04   0.08   0.42   0.20            L  O  S        B
 MAX DELAY  mins     0.06   0.12   0.82   0.32            VEH HRS      9.9
 AVE QUEUE   veh        0      1      7      2            COST  $   8933.0
 MAX QUEUE   veh        0      2     12      3
F1mode  F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

Year 2020 volumes without Bypass
LOS B with 13.5 secs average delay

```
 6:6:02              IDAHOM2020    SCHEME NAME                        11
 E     (m) _  7.00  10.00   6.00   5.00          TIME PERIOD     min      90
 L'    (m)   20.00  10.00  10.00  10.00          TIME SLICE      min      15
 V     (m)    6.00   5.00   5.00   5.00          RESULTS PERIOD min  15 75
 RAD   (m)   20.00  20.00  20.00  20.00          TIME COST     $/min  15.00
 PHI   (d)   30.00  30.00  30.00  30.00          FLOW PERIOD     min  15 75
 DIA   (m)   50.00  50.00  50.00  50.00          FLOW TYPE  pcu/veh    VEH
 GRAD SEP        0      0      0      0          FLOW PEAK am/op/pm     PM

 LEG NAME  PCU  FLOWS (1st exit 2nd etc...U) FLOF CL   FLOW RATIO    FLOW TIME
SR20RMP NB 1.05   55   51   63  0            1.00 50 0.75 1.125 0.75 15 45 75
IDAHOM WB  1.05  160  309  453  0            1.00 50 0.75 1.125 0.75 15 45 75
EMAIN SB   1.05    0  380   56  0            1.00 50 0.75 1.125 0.75 15 45 75
EMAIN EB   1.05   15  231  358  0            1.00 50 0.75 1.125 0.75 15 45 75

                               MODE 2
 FLOW        veh      169    922    436    604
 CAPACITY    veh     1542   1675   1153    933            AVDEL s      6.7
 AVE DELAY  mins     0.04   0.08   0.08   0.20            L  O  S        B
 MAX DELAY  mins     0.06   0.12   0.12   0.32            VEH HRS      4.0
 AVE QUEUE   veh        0      1      1      2            COST  $   3567.1
 MAX QUEUE   veh        0      2      1      3
F1mode  F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

Year 2020 volumes with Bypass
LOS B with 6.7 secs average delay

Note: Definitions for Roundabout Capacity Output are given in Appendix

The Rodel software allows for determining delays and vehicle queues based on a wider area of the delay data curve (a curve predicting delays based on volume to capacity ratio observed in the field). Since the curve is based on empirical data observed in the field, it represents the actual delays that can be expected for a specific v/c ratio. It is important to know on which part of the curve the analysis is based. Figure A6 shows a graph of this curve for roundabout delays (y axis) plotted along the v/c ratio (x axis).

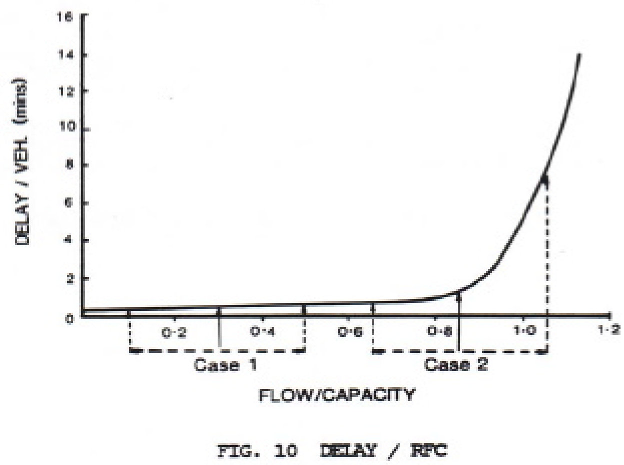


Figure A6 Expected Delay for Flow/Capacity (RFC)

It can be seen that the curve begins to sharply increase in delay at a point greater than a v/c ratio of 0.85. What this means, is that the delays for a roundabout can sharply increase with slight differences in volume, when the v/c ratio is greater than 0.85. It is important, therefore, to know if the roundabout is nearing capacity in the analysis, because it is possible that it could fail if ample reserve capacity is not built in. Traffic volumes can vary from day to day (up to 20%), and future traffic projections can also have some variance depending on land use assumptions, etc. The Rodel software allows for determining the potential delays with slight increases in volume (by using an 85% confidence level on the data curve), and if the v/c ratio is greater than 0.85, a roundabout calculating at LOS B could go to LOS F with the new part of the curve (assuming slight increases in traffic).

In our analysis we calculated LOS B for the roundabout without the bypass lane. However, with a slight increase in traffic it was determined that LOS F conditions would exist, due to being at the turning point on the delay data curve already. Due to this potential breakdown with only slight increases in traffic volume, it is recommended that the bypass lane be constructed, so that ample capacity will exist in the roundabout to account for slight errors in traffic projections, or in typical variations in traffic count data.

Effect of Bennett / East Main Street Signal

The modification of this intersection to realign the extension of Richardson Street to meet Bennett and Main Street, as well as the eventual installation of a new traffic signal is key to the success of traffic operations at the modern roundabout installation. The reason for this is due to the existing problem of traffic backup up on the westbound approach of East Main Street and Bennett Street. As traffic grows in the future it is probable that traffic could back up to the roundabout intersection, causing a breakdown in operations. Currently, the traffic does not even come near to backing up to the Idaho Maryland intersection. In order to prevent this potential problem in the future, it is necessary to provide adequate capacity at the intersection of Bennett and East Main Street. The realignment of Richardson Street extended to Bennett Street would provide a short-term relief, as capacity will be enhanced (traffic is expected to queue only one third of the distance back to Idaho Maryland Road) even with stop sign control. When a signal is installed, the intersection goes to LOS B for existing traffic levels. The queue on the westbound approach is virtually eliminated, indicating that it will pose no problem to the operation of the modern roundabout at the Idaho Maryland intersection. These conclusions have been fully verified with SynchroPro SimTraffic simulations.

Year 2002 Traffic Count Summary by 5 minute interval

Count taken August 28, 2002 4-6 pm, Peak Hour Data shown:

END Time	WBR	WBT	WBL	NBR	NBT	NBL	EBR	EBT	EBL	SBR	SBT	SBL	TOTAL
4:20 PM	16	18	25	7	6	6	1	10	29	31	25	3	177
4:25 PM	22	23	18	8	4	2	0	5	26	37	29	5	179
4:30 PM	16	14	31	8	3	3	0	7	22	37	29	6	176
4:35 PM	23	21	29	9	5	5	1	6	30	38	20	6	193
4:40 PM	19	28	30	3	11	1	0	10	22	35	27	2	188
4:45 PM	11	15	32	4	3	4	0	9	31	38	27	6	180
4:50 PM	15	13	27	3	5	4	0	5	16	40	32	5	165
4:55 PM	7	31	29	9	3	4	1	11	22	43	26	5	191
5:00 PM	17	26	30	6	6	7	1	9	25	32	25	3	187
5:05 PM	14	28	38	4	4	3	0	7	21	39	32	2	192
5:10 PM	8	18	27	8	4	8	1	9	26	33	26	2	170
5:15 PM	14	23	35	6	3	2	1	7	30	43	30	1	195
	182	258	351	75	57	49	6	95	300	446	328	46	2193

Source: PRISM Engineering using Petra and electronic count board

Rodel Year 2020 Calculation Discussion

```
  6:6:02                    IDAHOM2020ALT SCHEME NAME                       14
 E    (m)    7.00  10.00   6.00   5.00           TIME PERIOD     min      90
 L'   (m)   20.00  10.00  10.00  10.00           TIME SLICE      min      15
 V    (m)    6.00   5.00   5.00   5.00           RESULTS PERIOD min  15 75
 RAD  (m)   20.00  20.00  20.00  20.00           TIME COST     $/min  15.00
 PHI  (d)   30.00  30.00  30.00  30.00           FLOW PERIOD     min  15 75
 DIA  (m)   50.00  50.00  50.00  50.00           FLOW TYPE  pcu/veh    VEH
 GRAD SEP       0      0      0      0           FLOW PEAK am/op/pm     PM

 LEG NAME  PCU  FLOWS (1st exit 2nd etc...U) FLOF CL    FLOW RATIO    FLOW TIME
SR20RMP NB 1.05    55   51   63  0           1.00 50 0.75 1.125 0.75 15 45 75
IDAHOM WB  1.05   160  309  453  0           1.00 50 0.75 1.125 0.75 15 45 75
EMAIN SB   1.05   510  380   56  0           1.00 50 0.75 1.125 0.75 15 45 75
EMAIN EB   1.05    15  231  358  0           1.00 50 0.75 1.125 0.75 15 45 75

                                 MODE 2
 FLOW        veh      169    922    946    604
 CAPACITY    veh     1542   1675   1153    933            AVDEL s     13.5
 AVE DELAY  mins     0.04   0.08   0.42   0.20            L  O  S        B
 MAX DELAY  mins     0.06   0.12   0.82   0.32            VEH HRS      9.9
 AVE QUEUE   veh        0      1      7      2            COST  $   8933.0
 MAX QUEUE   veh        0      2     12      3
F1mode   F2direct  F3peak  CtrlF3rev  F4fact F6stats  F8econ  F9prnt  F10run Esc
```

The “confidence levels” (CL column in output) given in the output are set at 50% as a default. The most probable queues and delays are at the 50% confidence level, meaning that this is what is expected to happen. It also represents the level that must be used when comparing level of service (LOS) with traffic signal calculation methods. Signal LOS calculation methods have an implicit 50% confidence level. Sometimes a designer of roundabouts can plug in an 85% confidence level to see what happens when capacities are reduced and projected traffic flows are factored up. If the roundabout capacity was nearly fully utilized (i.e. LOS D/E) then it is likely that with a little more traffic, the roundabout will fail. This is because roundabouts can experience sharp increases in delay (the steep part of the empirical delay curve) when the V/C ratio exceeds 0.85.

The Rodel software allows for checking of this condition by varying the confidence level. When and if the level of service fails for the 85% confidence level, but yields satisfactory conditions for the 50% confidence level, this means that the v/c ratio is greater than 0.85 for the traffic volumes being used, and that more capacity should be designed into the roundabout to prevent the occasional failure when traffic volumes exceed what was projected or anticipated in the analysis.

Definitions in Output Results

E = entry width of approach	L' = length of flare curve
V = entry throat width	Rad = Flare curve radius
Phi = angle of traffic entry	Dia = Diameter of Roundabout
PCU = factor to account for trucks	CL = confidence level of statistics

The graph of delay plotted against capacity/flow (RFC) shown previously in Figure A6 illustrates how this curve gets steep as the volume to capacity ratio approaches 1.0, but is generally flat (meaning that delay is insignificant) up to a point where the volume to capacity ratio approaches 0.80. After this point the curve gets much steeper, indicating that delays and queues will increase sharply when the volume approaches capacity. This is normal and to be expected, even with signalized or stop control intersections.

It is not possible to estimate queues and delays precisely, as there is some uncertainty with traffic projections for the future, or even traffic counts for existing conditions. In addition, the capacity of a roadway or intersection can be subjective, if not based on empirical data, or measurements made on actual roundabouts of varying sizes and shapes. Queues and delays can only be estimated for a particular confidence level (either implicit or explicit). If queues and delays are estimated with a 50% confidence level, it is 50% certain that the actual queues and delays, apart from random variation, will not be greater than the estimated values. This level of confidence is typical of that used throughout the industry. Calculations shown in Table 1 were made with a 50% confidence rating, and are directly comparable to signalized options. As can be seen in Table 1, when an 85% confidence level is used in the Rodel software package, the level of service for the roundabout *without the bypass lane* could drop to LOS F, indicating that the size and shape of the roundabout versus the projected volumes for Year 2020 are just about evenly yoked. In other words, the volumes are high enough in the roundabout to be at the borderline of where the roundabout could break down in level of service. It is better to error on the safe side, and add the bypass lane to prevent this problem from occurring occasionally.

Even though it is likely (50% confidence level on the bell curve) that the roundabout will perform at LOS B conditions in the future most of the time, there is a chance that the volumes could be slightly higher from time to time, pushing the roundabout into poor levels of service. The only solution is to add more capacity. In our analysis results, it was found that a bypass lane mitigates this condition.

Analyses of Triad of Intersections:
1) South Auburn Street and Neal, 2) South Auburn Street at the WB Frontage Road/Onramp, 3) Colfax at the WB Frontage Road.

Traffic Counts, January 14, 2004, *one hour summaries in 15 minute intervals from 4:20 pm to 5:20 pm*

Idaho Maryland Onramp

Merge	Stay On	
149	35	
150	30	
164	27	
168	21	total
631	**113**	**744**

SR 20 at Bennett

Stay on	Exit	
346	90	
252	100	
179	117	
433	113	total
1210	**420**	**1629**

Frontage at Colfax

WBL	WBT	WBR	NBL	NBT
7	61	27	26	38
9	56	32	33	36
8	60	21	34	38
7	72	44	28	36
31	**249**	**124**	**121**	**148**

Frontage at Auburn

WBL	WBT	NBL	NBT	SBR	SBT
19	61	6	85	51	51
22	70	4	77	53	48
29	69	7	81	48	43
37	61	7	105	62	31
107	**261**	**24**	**348**	**214**	**173**

Auburn Onramp

Merge	Stay On	
86	31	
94	34	
96	42	
86	31	total
362	**138**	**500**

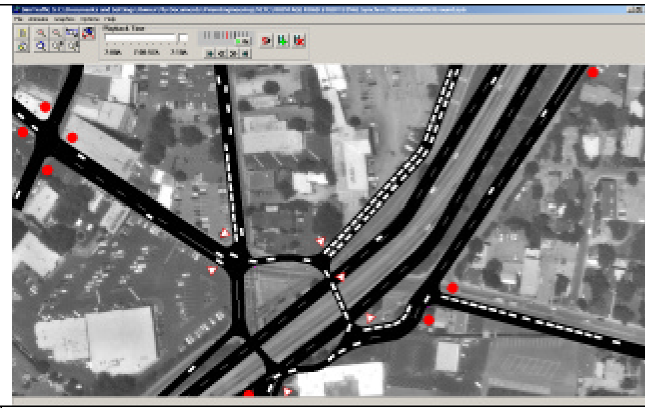
Empire Offramp

Merge	Stay On	
143	261	
188	281	
159	252	
212	263	total
702	**1057**	**1759**

Source: PRISM Engineering

Synchro Micro-Simulation Model "Snapshots" of PM conditions for Various Alternatives.

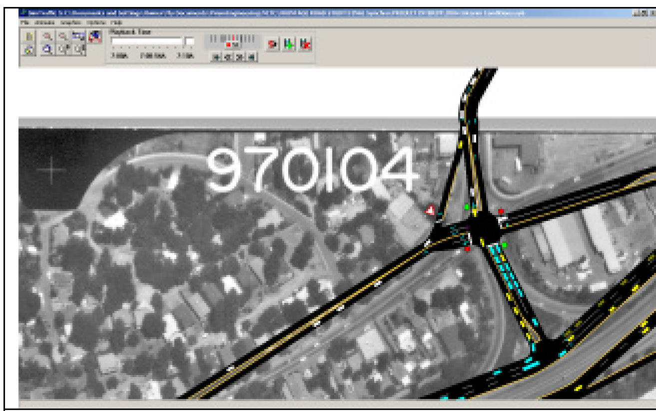
Single Point Intersection, PM Peak Hour



Roundabout Intersection, PM Peak Hour

Figure A7 Preliminary Alternatives for Triad of Intersections

Alternative, Year 2004 traffic with Idaho Maryland on-ramp traffic diverted to a single point intersection. Traffic does not back up beyond adjacent intersections. Also shown on right is Year 2004 traffic with Idaho Maryland on-ramp traffic diverted into a modern roundabout. Traffic backs up beyond adjacent intersections, and satisfactory LOS is not possible with proposed volume demands.



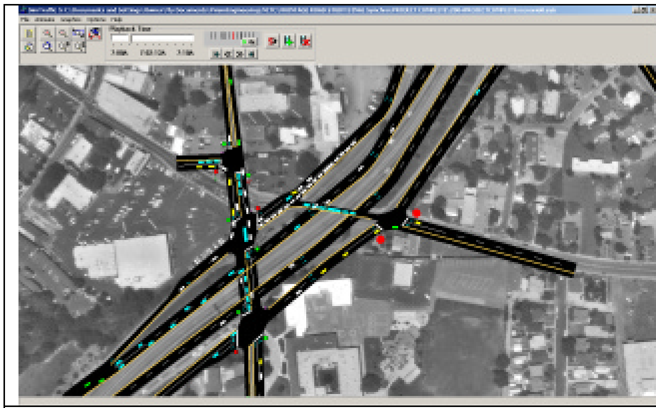
Idaho Maryland Intersection, PM Peak Hour

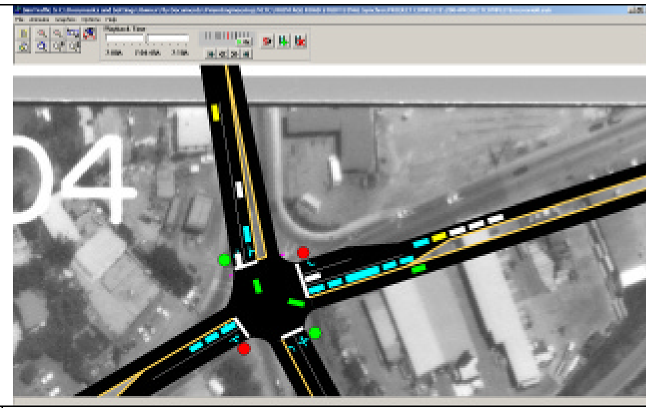
Bennett/E. Main Intersection, PM Peak Hour

Figure A8 Interim 2004 Conditions

Alternative, Year 2004 interim traffic with Idaho Maryland off-ramp traffic diverted to East Main Street. Traffic does not back up beyond LOS D conditions.

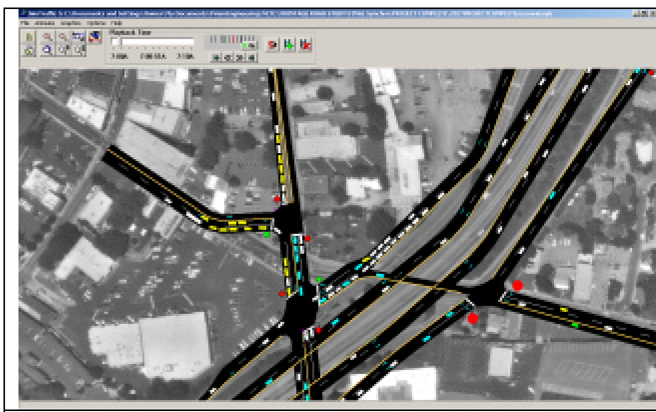
Project Complete Conditions, Year 2004-2006

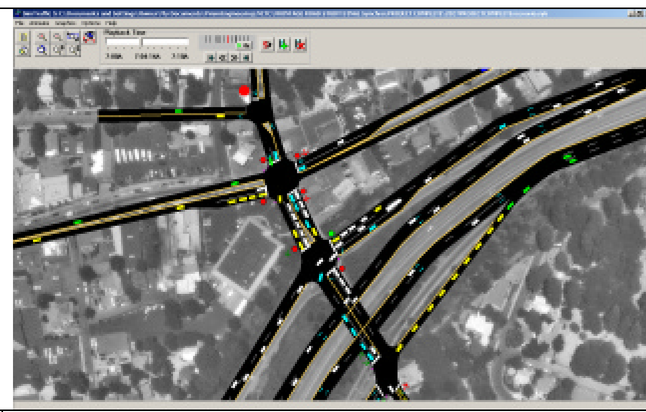




Triad Intersections Converted, PM Peak Hour	Idaho Maryland/E. Main, PM Peak Hour

Figure A9 Project Complete Year 2004-2006 Conditions





Triad Intersections Converted, PM Peak Hour	Idaho Maryland/E. Main, PM Peak Hour

Figure A10 Project Complete Year 2027 Conditions